HARDWARE.....SOFTWARE.....AT HOME.....IN BUSINESS

computing today

APRIL 1982
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70p

FOR A PERSONAL APPROACH TO MICROCOMPUTING

FEELING ADVENTUROUS?

Step into programming with our multi-system modular game

Our reviewers go colour crazy with micros from Texas and Tandy

Printing on Centronics's 739

Make the right connections with our series on interfacing

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LONELY Genie I Microcomputer, early eighties, with large peripheral family but currently unattached, would like to meet interesting, attractively packaged software, Genie or Tandy specification, for programming, problem solving, entertainment and long-lasting friendship. Reply in confidence. Box No RS232.

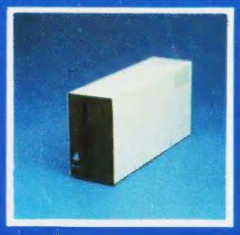
ANSWERING MACHINES

ingenious ...but lonely!

Buying your first Genie I microcomputer is just the start of a long and enthralling adventure, for it won't be long before you will want to expand your system with some of the wide range of peripherals which make up the complete Genie System.

Firstly there is the **Expansion Box,** which immediately expands your Genie's capacity to 32K RAM, and up to 48K RAM if required. It can be connected to 4 disk drives, a printer, RS232 interface or S100 cards.

Then there is the **Printer,** a compact unit with 80 column, 5 x 7 matrix print-out, which connects to your Genie through the Expander, or via the Parallel Printer Interface.



The **Disk Drive** gives you greater storage capacity and full random access file handling, with the option of double-density through a special adapter.
New Dual Disk Drive now available!

Finally, there is Genie's very own **12" Monitor,** a must if you want to let the rest of the family watch their T.V. in peace!
Available in B & W or green tube.

The supreme advantage of the Genie I system is its compatibility with the TRS 80, which means that literally 1000's of pre-recorded programs are already available, just waiting to be plugged into your Genie!

The recent improvements in the Genie system, including Extended Basic, sound unit and machine language monitor, make it the ideal system for the committed hobbyist, and an excellent and easy-to-use educational tool.

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Computing Today is constantly on the look-out for well written articles and programs. If you think that your efforts meet our standards please feel free to submit your work to us for consideration.

All material should be typed. Any programs submitted must be listed (cassette tapes and discs alone will not be accepted) and should be accompanied by sufficient documentation to enable their implementation. Please enclose an SAE if you want your manuscript returned; all submissions will be acknowledged. Any published work will be paid for.

All work for consideration should be sent to the Editor at our Charing Cross Road address.

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VOL 4 NO 2 APRIL 1982

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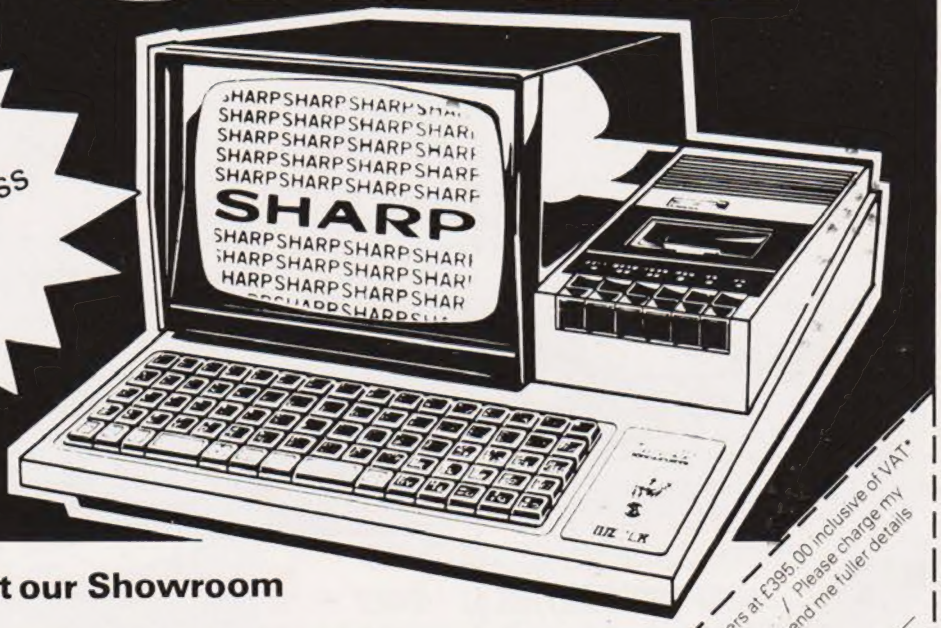

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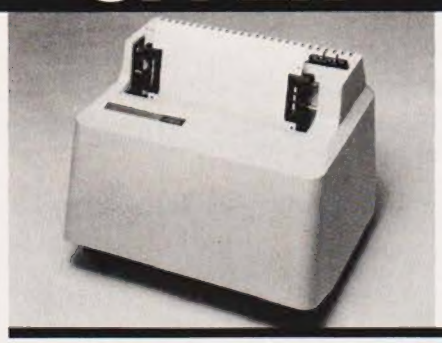

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STATESIDE

You have to have a sense of humour in this business. One of the best ideas in home video to arrive in recent years, we feel, is the Laser system developed by Philips and marketed in the USA by Magnavox. Recently US Pioneer was granted the rights to produce their own version of the unit they call the VP-1000 Videodisc Player, more informally called Laservision.

This month, an interface for the Apple II computer was announced by Aurora Systems Inc of Madison Wisconsin. Called Omniscan, it is designed to mate the VP-1000 to the Apple in such a way that software control of all videodisc functions are obtained. This allows the system to display information on the video screen (either a regular television or a monitor) with colour, STEREO sound and motion while allowing the computer user to interact with the material shown. This enables the computer and the video disc to be used as an interactive teaching system whose applications are limited only by the imagination.

The Associate Editor of Creative Computing Magazine, David Lubar, devised an interactive video/computer game using the new interface. And that's where the fun began! Creative Computing contacted Pioneer to borrow a player for demonstration at the upcoming Fall computer and home entertainment shows — but Pioneer refused to become involved. And if that wasn't enough, attorneys for the owners of the particular movie used on the video disc feel that the American Screen Actors Guild's contract prohibits the use of the movie; the assumption being made is that the movie disc is to be shown as a regular movie and nothing else. Remember that bit about the system being only restricted by the imagination, well, apparently these people have very limited imaginations. It is too bad that a potentially useful learning system is being hampered by people of little imagination and vision. Still, as I said earlier, it pays to keep your sense of humour in this business.

Crisis, What Crisis?

Last year Advanced Micro Devices, located in Sunnyvale (the heart of Silicon Valley), threw a gigantic Christmas party for their 6000 employees and guests. They spent $350,000 on that party celebrating the coming year of record profits. The anticipated profits not only failed to be realised but their last quarter's earnings (September — December) were down to $1.0 million compared with $7.0 million for the same period in 1980. This year, instead of a party, only employees hired within the last year and a half were invited to attend a company breakfast. The party is certainly over!

This situation is becoming typical in the Valley amongst virtually all of the major semiconductor manufacturers. Profits are off by as much as 65% and no one seems able to predict when things will turn around either. The Chairman of Intel Corporation (Santa Clara), Gordon Moore, said recently: "We're 18 months into a recession we thought might last six months — just as we have predicted every month for the past 12 — we should be out of it." The President of Varian Associates semiconductor division, Bill Bottoms, agrees: "The most consistent thing about our industry is that people are still saying the upturn is six months away."

Although recessions in the semiconductor industry are not uncommon, this time the situation is more serious than it ever has been. For example, when sales fell off 23% in 1975, company earnings fell 37%. This past year as sales decreased only 10%, earnings fell an average of 65%. The reason for this big difference is attributable to the falling prices of chips.

The automobile industry may have a significant effect upon the semiconductor market conditions, but probably not until 1983. It is predicted that semiconductor sales related to automobile production may be as great as $500 million by 1985. So some recovery is expected — but not too much and not too soon. Most of the prognosticators feel that there may be no increase in profits until the final quarter of this year. Even though the marketplace may expand tremendously in the next ten years, at the present time, the outlook is very painful indeed.

Bud Izen Davis, California

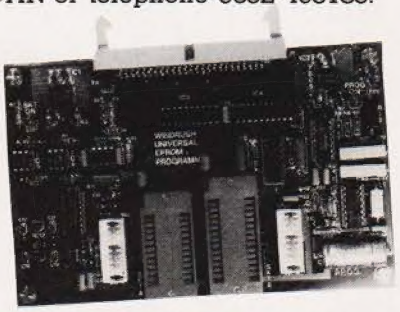
EPROMs TO PROGRAM?

A Universal EPROM Programmer has been purpose-built for 6800/6809 software/hardware development systems.

Among its many features, the device programs and verifies 2708, 2516/2716, 2532, 2732, 2732A, 2564, 2764 and the 128K TMS2528. There are also two zero insertion force sockets with mode selector switches provided, thus eliminating the requirement for additional 'personality' modules.

An extensive software menu allows the device to move a one byte to 16K block of memory to any point within a 64K memory map; to read 'EPROM into the buffer; to program the EPROM from the buffer; to program a selected area of EPROM; to verify the EPROM against the buffer; to examine and change the buffer; to carry out a formatted dump of the buffer; and to fill a selected area of buffer with a specified fill character.

Further data can be obtained from Windrush Micro Designs Ltd, Gaymer's Way Industrial Estate, North Walsham, Norfolk NR28 OAN or telephone 0692-405189.



COMPUTER CHAT

Is your computer engaging you in rather limited conversations? Celdis have the answer, a new ROM chip set now available priced at £35.42 which, with two 64K ROMs, adds a further 136 words to the standard 138 words already provided by the DIGITALKER speech synthesis system.

If you've never heard of the DIGITALKER (and if you read CT you should have), it is essentially a speech processor chip and speech ROMs which, when combined with an external filter amplifier and speaker, form a system that will generate high-quality speech. But then you knew that already, didn't you.

If you need more information get in touch with Celdis, 37, Loverock Road, Reading, Berkshire RG3 1ED.

CONSUMER NEWS

EXPANSION REDUCTIONS

For those of you completely fed up with inflation, here's news of Timedata who have recently reduced the price of their MZ163 range of Acorn ATOM compatible RAM expansion boards.

All single Eurocard size (100 x 160mm), these boards come in 16K and 32K versions allowing the ATOM's RAM space to be extended to 28K or 38K. The new prices, inclusive of VAT and UK p&p, for the 16K and 32K boards are, respectively, £59.50 and £74.00 for boards fitted with connectors allowing them to be fitted inside the ATOM's case, and £62.00 and £76.00 for boards equipped with the Eurocard standard DIN 41612 connector.

Full details can be obtained from Timedata Ltd, 57 Swallowdale, Basildon, Essex SS15 5BZ or on 0268-23234.

CAMBRIDGE COURSES

If you haven't been noting the course offered by Cambridge Micro Computers this year, now might be a good time to start!

This month there are two courses on offer: Structured Programming in BASIC, a three day course taking place from 5-7 April and Advanced systems design in Pascal, a five day course starting on the 26 April. Prices for the three day courses are £189 plus VAT and £349 plus VAT for the five day course. All courses are held at the company headquarters at the address given below.

Cambridge Micro Computers Ltd usually provide two different courses each month so even if the events above don't strike a chord, write to them at the Cambridge Science Park, Milton Road, Cambridge CB4 4BN or ring them on 0223-314666 for further details.

SORRY...

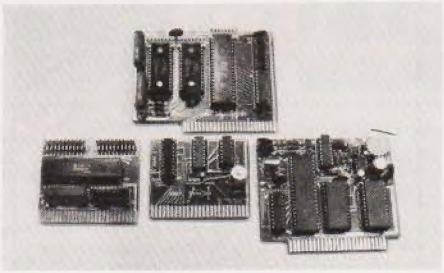
If any of you have had the problems one of our readers has experienced trying to get hold of a book we recommended, The Apple II Monitor Peeled by William E Dougherty, we do apologise.

Although assured to the contrary, we are now informed this book is unavailable in this country. However, you can get it direct from the author for $9.95 at the following address — 14349, San Jose Street, Mission Hills, California 91345, USA. If you have a VISA card it's even easier, just phone the code for America followed by the number 213-896 6553 and quote your VISA number.

Sorry...

EXTRA APPLE CARDS

A set of four new peripheral cards have been introduced for the Apple II and Apple III microcomputers.



The range includes MicroClock — a real-time clock with registers from tenths of seconds to leap years; MicroTalker — a speech synthesis card using the National Semiconductor DigiTalker chip set; MicroPort — a dual eight-bit parallel input/output card; and MicroSynth — a sound and music synthesiser card employing the AY-3-8912 device.

The MarchCard range is priced at £49.95 for all except the MicroTalker available at £84.95. Full details of this range and the further products they promise us are in the pipeline, so get in touch with March Communications Ltd, 14/16, Manchester Street, Liverpool L1 6ER or telephone 051-236 2000.

PRINTER INTERFACE

A serial interface is now available for the Roxburgh DP-822 and DP-824, 21 and 40 column printer mechanisms. Designated part number 822-824/RS, the board offers RS232C and 20 mA current loop facilities as well as baud rate (110-4800), parity and stop bit selection.

A single line buffer and a full 96 ASCII character set are also included, the character set being stored in a 2716 EPROM to enable alteration if required.

The interface board, measuring 160 x 100mm, comes in 12 and 24 V versions, both priced at £76.80 one-off.

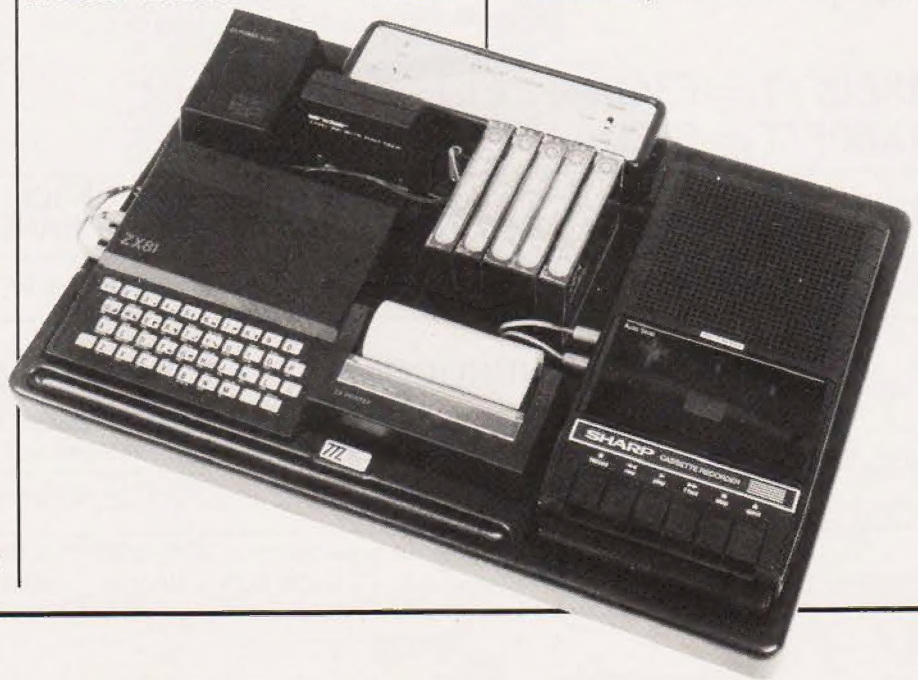
For more information on the 822-824/RS contact Roxburgh Printers Ltd, 22, Winchelsea Road, Rye, E Sussex TN31 7BR.

TOGETHERNESS! ▼

Ever have trouble keeping all your ZX81 bits and pieces tidy? If you do then take a close look at the desk console now available from Traffic Technology priced at £33.33 including p&p.

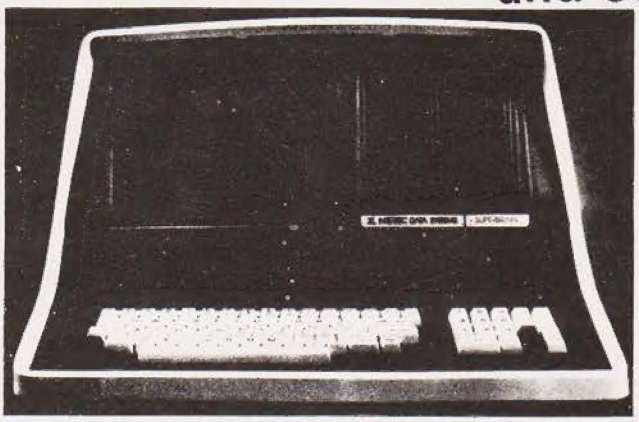
Moulded in heavy gauge black grained ABS plastic with detachable base cover and non-slip feet, the console can accommodate the ZX81 computer, a 16K RAM pack, a Sinclair printer, a power unit, a cassette recorder and a space for cassettes, pencils, etc. The console also includes a switch panel with a three-position slide control for SAVE/RUN-LIST/LOAD and a switch for 9 V power unit OFF/ON.

For more information on the desk console contact Traffic Technology Ltd, PO Box 2, Warminster, Wiltshire BA12 7QZ.



SALES-RENTAL

and other services



SUPERBRAIN 64K

APPLE CPM Z80

SUPERBRAIN 64K
£1600 SUPERBRAIN STANDARD MODEL (350KB DOUBLE DENSITY DISK DRIVE)
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APPLE 48K £600
320 DISC DRIVE WITH CONTROLLER

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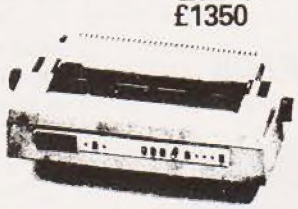

MX80F/T$_1$ = £340
MX80F/T$_2$ = £380

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180 APPLE JUICE POWER SUPPLY
5 APPLE BLACK & WHITE MODULATOR
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168 HEURISTICS SPEECHLINK 200
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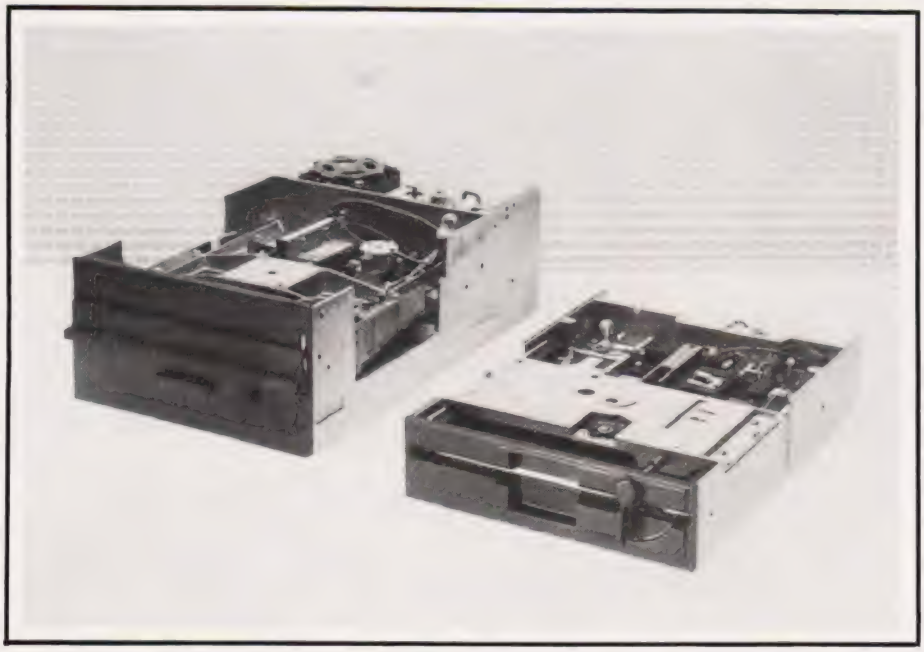


FLOPPY DUO – HALF THE SIZE ▲

Two half-height, 8" floppy disc drives allowing users to double existing storage capacity by placing two units in the space of one standard model has been announced by Shugart Associates.

The single-sided SA810 and the double-sided SA860 drives offer unformatted storage capacity of up to 1.6M and track-to track access times of only three milliseconds.

How have they done it? They replaced the AC motor used in most standard drive units with a fast-start brushless DC motor. Other key features include a programmable door lock for data security and optional metal shields on the side of the drive as protection against electromagnetic interference.

Current American prices are $385 and $450 respectively for the SA810 and SA860; production models are expected in this country soon. For more up to date information get in touch with Shugart Associates, 475 Oakmead Parkway, Sunnyvale, California 94086, USA or telephone (not forgetting the USA code) 408-733 0100.

EMPEROR MICRO

First time users may be interested in the smallest single-station microcomputer in the EMPEROR range, the EMPEROR 10.

Based on a Z80A processor, EMPEROR 10 offers 64K of RAM memory and 4K of EPROM. Using the CP/M operating system, the device supports COBOL, FORTRAN, BASIC, Pascal and PL/1 among others.

There is a wide range of software packages for the EMPEROR 10 from financial analysis to stock control, legal systems, etc. The system is also able to support word processing packages such as Wordstar and Easywriter.

The EMPEROR range is fully compatible and the EMPEROR 10 can be easily expanded to a multi-user, multi-tasking system just by adding a MicroVideo EMPEROR 20 or EMPEROR 30, both of which are supported by MVOST (MicroVideo's Multi Operating System) in the service processor.

The EMPEROR 10 is available for around £2000 for the basic unit, for further information get in touch with MicroVideo Ltd, 5/6, Yarmouth Place, Mayfair, London W1Y 7DW or 'phone them on 01-408 2017.

THE ESKIMO'S FRIEND

Weighing less than two kilograms and only a little larger than a book, the Husky 144 is a practical hand-held computer especially suited to outdoor environments and robust applications.

The Husky incorporates up to 144K of memory and can display up to 128 characters in four lines. It has also been designed so that the user can easily access information from the office main computer over a telephone line speeding up the processing of data.

Memory is maintained by three sets of batteries providing a good guarantee that no storage is lost.

The Husky 144 is priced at just over £1400 for the basic system providing computer technology to those outside the typical 'computer environment'. Further information can be obtained from DVW Microelectronics, 10, The Quadrant, Coventry CV1 2EL.

DURANGO – PLUS DISCS!

The DURANGO portable (?) business micro, incorporating one typewriter-size unit VDU, input keyboard, processor, memory and printer, is now available with built-in seven or 14M Winchester disc drives alongside standard floppy disc capability.

Already able to be expanded up to 196K, the DURANGO also offers the facility to link additional VDUs alongside.

The basic 64K DURANGO system inlcuding floppy disc drives and dual mode printer now costs from £5495 while a version including a seven megabyte Winchester disc alongside one

floppy is available from £7750.

For more information on the DURANGO system get in touch with Computer Ancillaries Ltd, 64, High Street, Egham, Surrey or 'phone them on 87 36455. And while you're speaking to them, ask them about their desktop business computer, the 800 XR, which offers data processing, communications and word processing all within a single integrated unit.

BUSINESS NEWS

THE INSCRUTABLE EXPERT

Direct from Sord Computer Systems of Tokyo, Japan, comes a new 128K microcomputer called the Expert.

Based on the Z80A microprocessor, the Expert has a monitor with full ASCII keyboard, two 320K disc drives, two RS232 ports and a parallel printer port. At a standard package price of £1950, the Expert includes not only the CBASIC language but also a new high level language custom-designed in Japan called Pan Information Processing System or PIPS for short. PIPS, ideal for the non-programmer, consists of around 100 commands for formatting and entering the user's own data to suit specialised requirements.

A colour monitor, priced at £515, can be added to the system allowing PIPS to be displayed in specific colours with varying backgrounds. For more Expert information contact Exleigh Business Machines Ltd, 11, Market Place, Penzance, Cornwall TR18 2JB or telephone 0736-66577.

ALPHA BETTA?

Based on the Motorola MC68000, a new single chip 16 bit processor designated AM-100/1 is now available across the full range of Alpha Micro systems including the new Winchester-based systems, AM 1020 and AM 1041. The AM-100/L is also fully compatible with all software available for existing systems.

Processing data internally in either eight-bit bytes, 16-bit words or 32-bit longwords, the AM-100/L features 15 32-bit registers plus a stack register and directly addresses up to 16M of memory. Other features of the processor include a programmable real-time clock, two serial I/O ports with programmable baud rates, clock/calender with battery back-up, and diagnostic display interface.

The price of the AM-100/L is very dependent on the system it is added to, however, given the example of a medium-sized system with three VDUs and a printer plus the AM-100/L, the price would be around £15,000. For more information, get in touch with Alpha Micro Systems UK Ltd, Alpha House, 13-27, Brunswick Place, London N1 6ED or call them on 01-250 1616.

THE EXPANDABLE ONE ▲

Aimed at both business and professional users, the ITT3030 microcomputer system is available in a basic version comprising a central processing unit, keyboard and software for around £2500.

The central processing unit is based on the Zilog Z80A microprocessor with 64K of memory and incorporates two 5¼" floppy disc drive units, each with a capacity of 280K. There is also a separate, extended word-processing keyboard, the CP/M operating system and MPSL's BOS operating system with the AUTOWRITER and the AUTOINDEX packages. The ITT3030 also has an RS232 port and by adding a multiple RS232 interface card can be transformed into a multi-user installation.

In much the same way, simply by taking out one PCB and inserting another, the ITT3030 processor can be upgraded from the eight-bit Z80A to the 16-bit Intel 8086. Similarly, the internal memory can be expanded from the basic 64K to 256K.

Further details of the ITT3030 can be obtained from ITT Consumer Products (UK) Ltd, Chester Hall Lane, Basildon, Essex or by 'phoning 0268-3040.

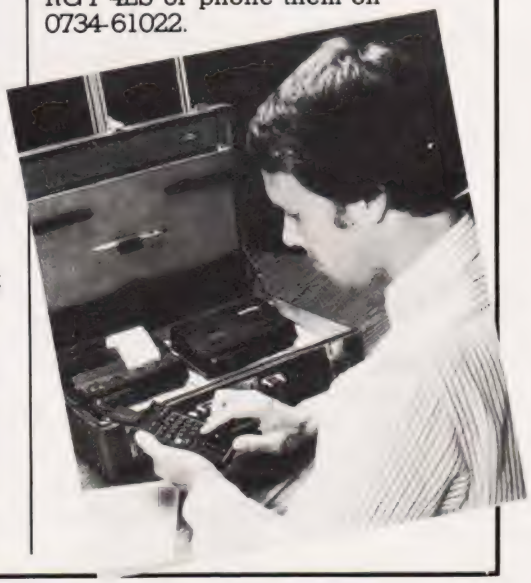
QUITE A HANDFUL ▸

Hewlett-Packard have introduced an interface, HP-IL, that allows HP-41C and HP-41V hand-held computers to control instruments and peripherals.

The HP-IL interface, priced at £79.79, enables the computers to control and read data from a new HP digital multimeter, and to interact with a new digital tape cassette drive and a new thermal printer/plotter. The new peripheral range is available at £453 for the digital mulimeter, £354.92 for the digital cassette drive and £319.42 for the thermal printer/plotter.

Also announced is the HP-IL converter, priced at £806.63, designed to be built into third-party devices such as measurement instruments. The converter connects the internal electronics of the instrument to the HP-IL loop allowing the HP-41 to control it.

The HP-41C and HP-41V are available from Hewlett-Packard at £159.58 + VAT and £207.45 + VAT respectively. For further information contact HP at 308-314, Kings Road, Reading, Berkshire RG1 4ES or phone them on 0734-61022.



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The micro comes of age. The PET has come a long way since micros were regarded as toys. It's designed and built for demanding work and this shows in the 32K memory and 80 column screen as well as in its impressive disk capacity. When it comes to languages, you'll find the PET fluent in BASIC, PASCAL, FORTH, COMAL, LISP, PILOT, FORTRAN, APL and ASSEMBLER.

It can be used as a complete system in itself, or can be linked to other PETs or a mainframe.

Who needs PET? And why? The list above speaks for itself, but that's only part of the story as the PET now has over 600 applications. It's good news for any engineer who's tried to get even a modest budget approved – the PET is very acceptable to the most sceptical of money people.

It's an attractive proposition, too, to DP professionals who need their fingers on the pulse and are fed up with waiting for their turn on the company computer.

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The PET has track record. We've been involved with electronics for over 20 years and there are now over 30,000 PET installations in the UK. We manufacture our own microchip which is happily accepted and used by makers of other well-known microcomputers.

You get nationwide dealer back-up with Commodore. What's more, many of our dealers have specific expertise – which means they can advise on anything from business systems to specialist technical applications. So, if your particular problem is of a highly specialised nature, it may be best to contact our Information Department direct. They will then recommend the dealers who understand – and who speak your kind of language.

What does all this cost? Not a lot. In fact, our computers start at £200 and go through to £8,000 – which will buy you a business system. That's just one more reason why any professional worth his salt would be interested in a microcomputer that's made its name in the business world . . . but is far more than just an efficient business brain.

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SUBMISSIONS

Are you interested in writing for our magazine? Or, to put it another way, are you interested in writing for your own magazine? Computing Today is always on the look-out for interesting articles, innovative programs and useful projects and we are sure there are many readers who have the capability to pass on their hard won knowledge to others. Not only will this make the magazine a better one, it will also put some money in ***your*** pocket to further finance your computing.

Featuring You

The main bulk of the magazine is usually taken up with feature articles, reviews, projects and general topics. Each of these articles attempts to convey the necessary information as clearly and concisely as possible, at the same time remaining easily readable. Articles of this nature can be thought of as similar to a school 'essay' in that they must have a beginning, a middle and an end. Diagrams and photographs are an enormous help to any article, the old adage of a picture being worth a thousand words certainly holds true in this case.

If you are a regular reader of the magazine you will know the 'style' in which we write. Generally each section of the article dealing with a new topic is given its own heading and, while not essential, headings do help to increase the readability of the final text. We prefer all copy to be typewritten on one side only of a page, using double line spacing and with large margins on each side of the text.

All associated diagrams and photographs should be clearly labelled both as to their intended use and as to where they relate in the text. Circuit diagrams should follow the standard style of component designation and layout that is used throughout Computing Today. All components used in a given circuit must also be listed in a single table or Parts List to avoid any possibility of confusion.

Programming For All

In general, the format for computer programs follows that of articles. We ***cannot*** accept any program which is not accompanied by a full listing and tapes on their own are totally unacceptable. While it is desirable to have a printed listing, it is not at all reasonable to expect everyone to have access to a printer so typewritten copy will be considered.

Remember to include sufficient detail to enable people who don't own an identical piece of hardware to be able to follow your program. You must also include descriptions of any part of the software unique to your machine; SYS calls, POKEs, etc. All graphics characters must be detailed with their associated codes and cursor controls presented in the CT standard format. The use of printers which give graphical output is acceptable provided all the graphics are fully explained. It is often worth including a photograph or drawing of the display produced or an actual sample run if possible.

Remember that the frustration you feel when you can't run a program (due to lack of documentation) will be felt by everyone else if YOU send in a program in the same state!

Soft Spots?

The Softspot features are really programming ideas submitted by readers. Because of this they do tend to be for specific systems. They must be submitted in the same format as other programs, ie printed or typewritten, but will probably contain less general detail and more specific machine instruction. The more detailed a program submitted for a Softspot the more chance of it being considered as a feature in its own right!

Paying For It

It takes up to four working weeks for any submitted material to get through the system. At the end of this period a decision is made as to whether it is acceptable or not and, if it is, a letter will be sent informing you of its acceptance and the rate offered. If it is found unsuitable we will return the program or article at this stage.

All payments are made upon publication, that is you will receive your cheque in the same month as the magazine appears on the streets.

The Right To Copy

Once it has been published, copyright of the material passes to us. Under special circumstances this copyright may be retained by the author but this ***must*** be negotiated at the submission stage. Because we own the copyright it is a breach of publishing law to reproduce the material anywhere else without the express written consent of the Editor. Under no circumstances may a program be republished for profit: the penalties are high.

Benefit To All

Writing for a magazine like CT not only gives you the pleasure of knowing that some 75,000 people read what you have written, but also goes some way to paying for that new piece of equipment you have set your sights on.

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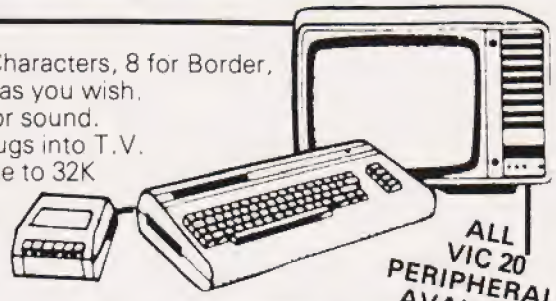

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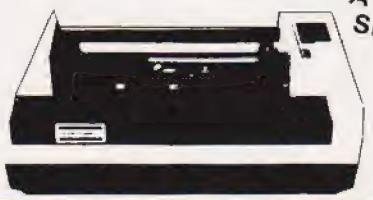

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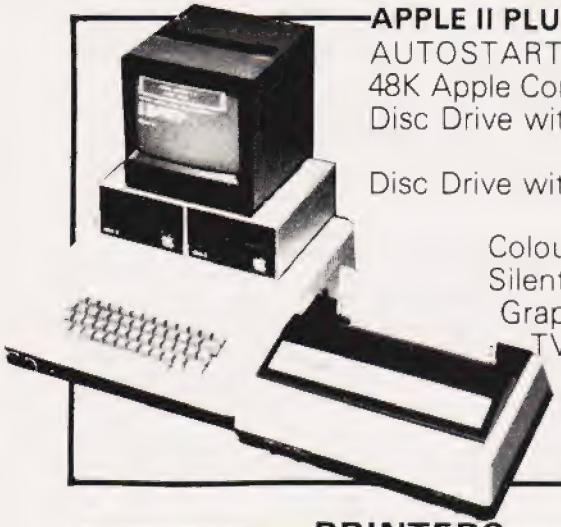

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ACCESS

Les May

VIEWPOINT

Opening our new page of commments on the micro industry is a piece on the problems of producing programs for the educational market.

Any teacher employed by an Local Education Authority far-sighted enough to set aside cash for a three-year programme to thoroughly equip each secondary school with microcomputers, printers and disc units, must count themselves very fortunate in these days of more and more demands made on less and less cash. When cash is made available to schools to spend in the way *they* require with a minimum of strings attached then indeed one is very fortunate. In fact, almost the only condition about how the cash should be spent is that all equipment should be of the same manufacture throughout the Authority: a condition imposed to ensure maximum software compatibility between different schools. Yet it seems to me that it is in the area of software provision that many well-meaning schemes may flounder.

The Root Problem

The April editorial of Educational Computing, commenting upon what was evidently felt to be widespread pirating of educational software, said 'Most of the best educational software being written is from those whose main job is to write programs. A considerable amount of software from full time educationalists (I think they mean teachers) cannot stand comparison'. As the software I have seen is overpriced and rather poor, I assume I have not seen the 'best'. In any event, can one really expect any teacher to buy a program he or she knows nothing of except the advertiser's information? Suppliers would rightly reply that an inspection copy service, common enough in the book business, would not work because teachers could simply pirate the programs rather than buy them.

Hidden within these two sentences there is however something much deeper. I read them to say 'teachers cannot do the job of programmers but programmers can do the job of teachers'. How a programmer can acquire overnight the skills of three or four years' training and many years' job experience is not explained. That teachers cannot do the job of programmers is on the whole true in my opinion. We can all cobble together a program to administer maths drill but it seems hardly likely that most teachers can acquire the skills of a professional programmer.

An Easy Answer?

If teachers cannot afford to purchase the programs that are available or they are unsuitable, what can be done? An easy answer is for a course in BASIC to be organised at the local teacher's centre. Why this has not been done before, I really do not know. Nor I suspect do the organisers. Another answer has been to organise working parties based on a town or city with a view to writing software 'packages'. Given the potential demand for software I cannot see even the most dedicated teachers satisfying it. If you doubt this, ask a programmer how many lines of good quality, thoroughly debugged software can be written in an hour.

In reality, these are simply stopgap measures which go no way to solving this problem. Before we can solve the problem we have to know where educational computing is going and at the risk of oversimplifying, there seem to be three areas where microcomputers have a role.

First, there is Computer Studies. Lack of software hardly seems a problem here! Second, and to my mind the most undervalued, is the use of computers in control applications. Once again the software problem is very small. Perhaps the real problem is to find the right high-level language because BASIC, for all its virtues, is not the most suitable. FORTH is deserving of a least a passing glance in this application.

The crux of the software problem lies in the third area, that of Computer Assisted Learning (CAL) under one of its many guises. It is in CAL that the demand for software is almost unlimited.

A Real Alternative

It will be apparent that I have little enthusiasm for some commercial software and little faith in a slight acquaintance with BASIC being a qualification for teachers to write good software. There are, however, two observations I would like to make. First, from the point of view of the teacher, it makes little difference what language the software is written in provided only that once loaded, the computer can use the program. Second, that what we call computer programming is in fact two quite separate processes. Before the educational program can be written, the objectives have to be set, the individual steps by which the final objectives are to be achieved have to be decided, the appropriate remedial action to be taken when any particular step is not understood has to be decided and the criteria must be established to assess whether a pupil has fully understood the topic. The other and quite distinct process is the coding of all these criteria into a form the computer can run as a program. The former is precisely the process a teacher will follow in preparing a lesson and involves no computer at all!

On the other hand, the programmer's predominant skill is in the latter, though no doubt the systems analyst could give some useful advice to teachers about lesson planning. In writing educational software the two skills complement each other but exist independently.

We still have not reached the stage of having a micro in every school, yet if the software logjam can be removed, there is a potential market for a least one micro in every — well almost every — classroom. Someone must grasp the nettle. Who will it be?

Following the reaction to a feature we recently published called 'The Teacher's Tale', we are throwing open a page a month for comment and opinion on the micro industry in general. Submissions for this feature should be between 1500 and 2000 words in length and a flat fee will be paid on publication for any material we use.

Opinions expressed on this page are those of the author and are not necessarily endorsed by the Editor.

NEXT MONTH

TIPPING THE BALANCE

In the professional computer market one of the most common reasons given for buying a personal computer is that it will provide the same sort of functions as the company mainframe. If it provides the same facilities however, there seems to be no reason for buying it! Wrong. The company computer is often so overworked that the staff who need time for data processing or report writing can't get onto the system. So, in an effort to solve their own problems and, incidentally, relieve some of the pressure on the company computer they buy the same sort of system as you have at home, a personal computer.

The real shock comes when they start to use it. Almost without exception they find that they can get the results quicker, they can modify and adapt the programs to suit their personal requirements and, before long, the system becomes just what they always wanted from the mainframe but could never have.

In order to test out this theory and see just how close a personal computer could come to a mainframe in terms of performance, we gave a £7000 graphics system to a £1 million mainframe user. The results of the test are revealing, to say the least!

COMPILERS

More and more companies are now offering BASIC compilers to go with their personal computers. They can certainly speed up your programs but are they as easy to use as the old-fashioned interpreters that we've grown to know and love?

In order to find out, we've taken a commercial package intended to give you the best of both worlds — development by interpreter and running by compiler.

A SOFT SOLUTION

One of the major stumbling blocks with 6502-based computers is that they are unable to access the vast library of CP/M software. The reason for this is because CP/M was written to run on 8080 and Z80-based systems; a classic case of system incompatibility. The solution for one top selling system, the Apple, was to go soft. By adding a special card with a Z80 processor and some specially written software to the Apple, it thinks it's a 6502-based computer running CP/M.

The product is called the Softcard and in next month's issue we'll be taking a look at how it can transform your computer.

AFTERMATH

The BBC has just started the second showing of its ten-part series on micros, The Computer Programme. With the micro itself already selling in large quantities and the Computer Book riding high in the bestseller lists, the question of 'what happens next?' rears its ugly head.

We have been talking to the series makers and the computer manufacturers to see just what is coming next. The one thing that's certain is that you are not going to be left staring at a blank screen wondering what to do next — at least not if they have their way!

REFLECTIONS

Producing complicated graphics patterns on screen often seems to be an endless task. However, many of the patterns we make are really repetitions of a single, simple structure. In a new series starting next month we show you how to take the drudgery out of programming complex patterns by letting the micro do all the hard work for you.

Articles described here are in an advanced state of preparation but circumstances may dictate changes to the final contents.

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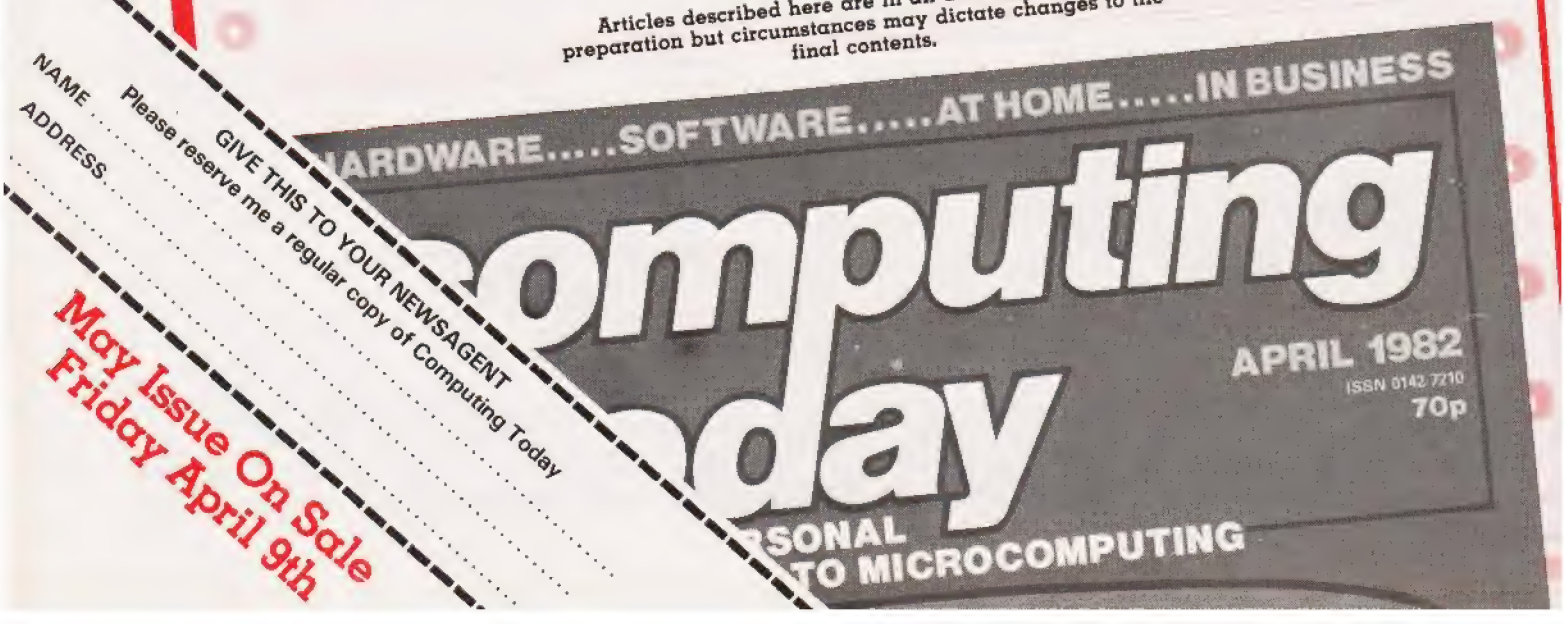

TTLs

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7410	12p
7411	20p
7412	20p
7413	22p
7414	32p
7416	25p
7417	25p
7420	16p
7421	20p
7422	22p
7423	22p
7426	30p
7427	25p
7428	28p
7430	15p
7432	25p
7433	27p
7437	27p
7438	27p
7440	17p
7441	70p
7442A	50p
7445	60p
7446A	93p
7447A	45p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	30p
7474	23p
7476	30p
7480	50p
7483A	45p
7485	60p
7486	20p
7489	210p
7490A	30p
7491	45p
7492A	30p
7493A	30p
7494	40p
7495A	50p
7496	45p
7497	120p
74100	86p
74107	130p
74109	140p
74116	60p
74118	75p
74119	90p
74120	70p
74121	27p
74122	45p
74123	40p
74125	40p
74128	40p
74132	30p
74136	32p
74141	65p
74142	200p
74145	50p
74147	100p
74148	75p
74150	60p
74151A	45p
74153	45p
74154	60p
74155	50p
74156	50p
74159	100p
74160	60p
74161	60p
74162	60p
74163	60p
74164	50p
74165	55p
74166	70p
74170	140p
74173	65p
74174	60p
74175	60p
74176	50p
74177	70p
74178	100p
74180	50p
74182A	130p
74182A	90p
74184A	90p
74185	120p
74186	500p
74188	325p
74190	50p
74191	50p
74192	50p
74193	50p
74194	70p
74195	60p
74196	60p
74197	60p
74198	100p
74199	100p
74221	60p
74259	150p
74278	150p
74279	80p
74283	75p
74284	200p
74285	200p
74290	200p
74293	100p
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74366	40p
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74LS15	30p
74LS20	15p
74LS21	15p
74LS22	15p
74LS26	15p
74LS27	18p
74LS28	18p
74LS30	14p
74LS32	14p
74LS33	16p
74LS37	16p
74LS38	16p
74LS42	40p
74LS47	40p
74LS51	15p
74LS55	30p
74LS73	75p
74LS74	20p
74LS75	28p
74LS76	20p
74LS83	45p
74LS85	55p
74LS86	16p
74LS90	35p
74LS92	40p
74LS93	35p
74LS95	45p
74LS96	110p
74LS107	45p
74LS109	30p
74LS112	34p
74LS113	30p
74LS114	30p
74LS122	42p
74LS123	50p
74LS124	120p
74LS125	30p
74LS126	30p
74LS132	45p
74LS133	30p
74LS136	30p
74LS138	34p
74LS139	36p
74LS145	75p
74LS147	160p
74LS148	90p
74LS151	30p
74LS153	40p
74LS154	200p
74LS155	40p
74LS156	40p
74LS157	35p
74LS158	36p
74LS160	40p
74LS161	40p
74LS162	40p
74LS163	40p
74LS164	45p
74LS165	100p
74LS166	90p
74LS170	90p
74LS173	70p
74LS174	60p
74LS175	50p
74LS181	140p
74LS190	50p
74LS191	50p
74LS192	50p
74LS193	60p
74LS194	40p
74LS195	50p
74LS196	60p
74LS197	65p
74LSZ21	60p
74LS240	80p
74LS241	80p
74LS242	80p
74LS243	80p
74LS244	65p
74LS245	90p
74LS251	40p
74LS253	40p
74LS257	45p
74LS258	40p
74LS259	90p
74LS260	24p
74LS266	25p
74LS273	70p
74LS279	45p
74LS280	250p
74LS283	45p
74LS298	160p
74LS299	450p
74LS323	250p
74LS324	180p
74LS348	150p
74LS365	32p
74LS367	32p
74LS368	50p
74LS373	80p
74LS374	80p
74LS376	50p
74LS377	70p
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IT INFORMATION TECHNOLOGY 82

IT INFORMATION TECHNOLOGY 82

Simon Goodwin

Just what does turn all that BASIC code into something the computer can run? The answer is a special program called an Interpreter.

Almost without exception the current range of personal computers use an 'interpreted' BASIC as their main language. This means that when you enter a normal BASIC program you are not loading the computer memory with the machine code instructions your processor will execute when you type RUN. Instead you are loading a stream of symbols which describe what you want to do to a large machine code program called the 'interpreter', this then executes many thousands of instructions trying to work out what you want to do. An interpreter looks at a set of 'rough notes' (rather like shorthand) and then uses a kind of programmed initiative to work out what the symbols mean and to carry out the appropriate operations.

This process is fundamental to an understanding of how a micro-based system works: this article will explain (in general terms) how your interpreter executes a BASIC program. We'll also compare the common interpreters with 'compilers', explaining the difference between the two and next month we'll take a detailed look at a commercial micro-compiler. Whether your computer is an Apple, PET, TRS 80, Sharp, NASCOM or whatever, the principles used are much the same.

Interpretations

Take this simple program line as an example:

```
10Ø  A=B+1:GOTO 2ØØ
```

We'll assume that it is a single line from a larger program, and that a while ago you typed RUN and the computer has just reached the line above. It looks at the first part of the line, after the line number, and scans through it until it finds a character that is not alphanumeric — in this case, the equals sign. It then looks at the character it has read so far (the letter A) and checks that it is not a reserved word (LET, IF, GOTO, etc). In this case it decides that 'A' is not reserved.- Consequently the computer assumes that the statement is an assignment. If your BASIC requires you to use 'LET' statements then it would give an error message at this point, but most popular interpreters permit LET to be optional.

The interpreter assumes that 'A' is a variable name. A routine is called to search a table of current variables. This is set up as the program runs and comprises a list of variable names and their values. The routine will search through for the name 'A'. When it finds the entry it will store its memory address in an area of RAM reserved for the use of the interpreter (either on the stack or in a fixed place). The main section reads further and finds the name 'B'. It calls up the variable-search routine again which tries to find 'B' in its table. If it can't find it, the routine creates a new entry at the end of the table enabling it to find that variable the next time it is needed. Most versions of BASIC (but not that on an Acorn ATOM) will set the value of the variable to zero when it is created.

The search routine is finally able to return the address of the variable B to the main interpreter. The main program can now look at the fourth character on the program line! It finds the plus sign (which also marked the end of the name B) and makes a note that it will have to do some adding — but first it must work out what to add. It reads further and locates the figure '1' then the colon which signifies the end of the statement. Other types of BASIC might use a different character to mark the end of a statement — on a Sinclair computer, for example, the end of the line signifies the end of a statement since only single-statement lines are allowed.

Now the computer calls a routine to convert the figure '1' from its format in the BASIC program (an ASCII character with code 49) into the binary format used by the microprocessor. When you type in your program, you enter the numbers in base ten using one character for each figure. When your computer does arithmetic in base two it uses one character for every eight figures! Consequently the interpreter has to use a quite complicated routine to convert numbers from decimal to binary. Even though in this case we are only converting a single-digit number (in either base!), the routine used must work for all lengths of number allowed by the system and make the appropriate changes if it finds a minus sign or a decimal point. Once it has discovered the correct value, it can call a relatively short subroutine to actually add what it has worked out to the number in the workspace area. Once the calculation is complete, it retrieves the location of variable A (remember variable A?) and stores the result there.

Location	Contents	Meaning
10F9	00	Header
10FA	02	Pointer to next line
10FB	11	
10FC	0A	Line number
10FD	00	(10 in Hex)
10FE	41	A
10FF	B4	=
1100	35	5
1101	00	Newline
1102	0A	Pointer to next line
1103	11	
1104	14	Line number
1105	00	(20 in Hex)
1106	42	B
1107	B4	=
1108	38	8
1109	00	Newline
110A	13	Pointer to next line
110B	11	
110C	1E	Line number
110D	00	(30 in Hex)
110E	9E	PRINT
110F	41	A
1110	2C	
1111	42	B
1112	00	Newline
1113	00	End of program marker
1114	00	

Fig. 1. How a short section of BASIC is stored in the memory. The program reads from top to bottom and the BASIC has been tokenised.

Hardly pausing to catch its breath, the interpreter now has a look at the next statement. It checks that GOTO is a valid word — this is where your WHAT...IF and IF...NECESSARY statements get thrown out. In the case of this line, the GOTO part tells the interpreter to get ready to change line numbers. It reads the next part of the statement — the line number — and converts it into a binary number. Then it will merrily search all through the program lines in the memory trying to find a line with a number that matches the one in its buffer. If it finds one, it stops searching and gets ready to work out or 'parse' the first statement on the new line. If it fails to find a match

anywhere in the program, it gives up and prints an error message; unlike the case of variables, it is not considered good form for an interpreter to create a new line of program if it can't find the one requested! The only computer which comes close to doing this is the ZX 81 which jumps to the line with a number closely following the one chosen if you try to GOTO a line which isn't there.

Too Slow?

That was a simple example of the execution of a program line but is summarises the workings of virtually all BASIC interpreters. Various programming tricks are sometimes used by their authors to make the program text easier for the interpreter to parse or to convert; reserved words may be compressed into special character-codes, or pointers may be used to help the interpreter finds its way from one line to another. Whatever methods are used, a relatively small proportion of the time during the running of an interpreted programme is taken up in searching through tables in memory or in converting information from one format to another.

All this may not worry you much as a personal computer user. So long as the machine can do it faster than you can work it out on your fingers or at the typewriter, all is well. Sooner or later, however, you will find that your program isn't running quite as fast as you would like. Maybe it is the unnerving way the Space Intruders judder to a halt when you try to move your laser and shoot them at the same time — maybe it's the long wait while your computer sorts your massive list of friends into order of protocol. Either way the fact that the computer is executing a few thousand machine instructions every second doesn't seem to help much. You will probably have come across a variety of suggestions to be used to speed up programs — peculiar things like using as few variables as possible, putting your subroutines at the start of the program, using variables instead of constants, etc. Maybe this article will explain how some of these tips are of use in reducing the overheads imposed by the interpreter.

Another chronic problem when a computer uses an interpreter is the way it never learns by its mistakes. You would expect any sensible machine, surely, to know where line 200 is after it has been sent there a few times? Unfortunately this is not the case; each time the interpreter executes a line it has to start working out what the contents mean from scratch.

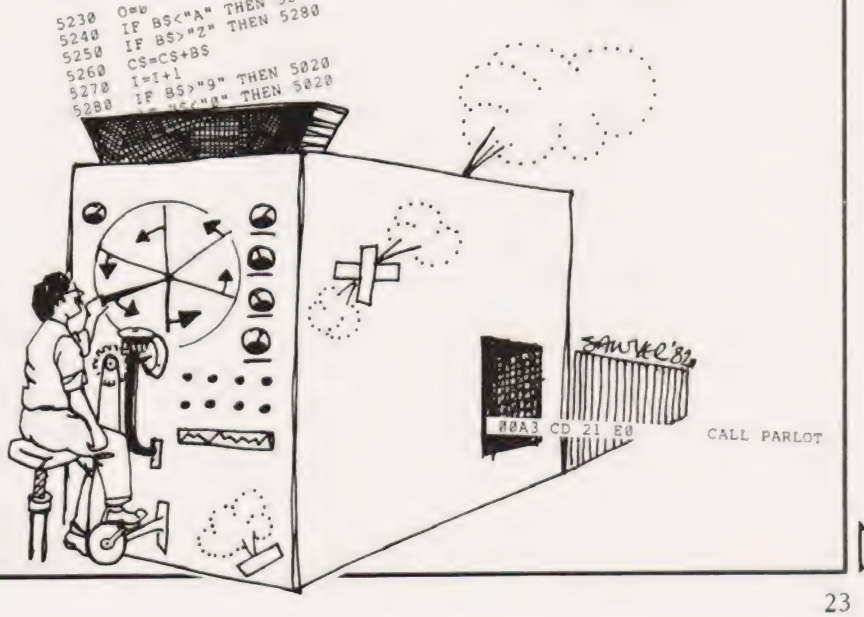
Hopefully you have now guessed what a compiler does. It translates a program written in 'source' form — the PRINT and INPUT statements you are used to writing — into a program which the processor can execute more or less directly, without all that searching and conversion. A compiler usually makes two or more 'passes' or repeated searches through the program text from start to finish. Usually the computer must be told by a special command to compile the program before it can be RUN at all. There is a vital difference here between compiled and interpreted programs: when you type RUN under an interpreter, you are telling the 'editor' (a part of the BASIC which allows you to type in lines) to start executing the interpreter; when you type RUN under a compiler, you are telling the computer to actually execute the machine-code generated when the source was compiled. A few compilers will operate automatically when you type RUN — they compile and execute as one step, as far as the user can tell. Some will compile each line as it is typed in although these are not usually as efficient as the ones which treat compilation as a separate process.

Generally a compiler will first pass through the program text working out where each line will be in the final code and reserving space for the variables used. Once that analytical pass is complete, the compiler is able to go back through the BASIC program, converting GOTOs and similar instructions into direct machine code jumps to the lines concerned, having worked out the appropriate addresses earlier.

All the variable references are converted into simple instructions which tell the processor to transfer information to and from memory. Constants (eg 32767, 0.778, 1.6775E-6, "TOAD") are converted from the text typed by the programmer into binary that can be easily used by the micro. It is usually still necessary to provide some routines outside the actual program code — for example, most microprocessors cannot handle floating-point calculations internally — so these functions are set up as subroutines and either built into a 'library' at one end of the compiled program or inserted into the code when they are first used. Unless the subroutine is a very simple one, it will only be built in once. Other parts of the program that need it will just call it when necessary by loading memory or registers with the parameters (the data to be processed and a note on where to put the result). Then it calls up the required routine. The final result is a machine code program which will do everything that the equivalent BASIC would have done — but maybe ten times faster!

The Reasons Why

At this point it is worth considering the advantages of using an interpreter. The most important advantage becomes apparent when you try to modify a compiled program... you will usually have to reload and recompile the entire source listing before you can test even a one-line change. Once a program has been compiled the original text is no longer in the



computer memory and the machine code that replaces it is almost impossible to modify.

In the compiled program you cannot simply insert a few extra instructions; the rest of the program relies upon the fact that the instructions (variables and so forth) are in fixed places, worked out when you first compiled. After you have changed a compiled program those addresses will probably be wrong. A jump which used to send you to line 100 of the original program might now drop you into the middle of the previous line. The source program must be translated again before it will work. An interpreter makes a search for each item of data whenever it is refered to, so the problem doesn't arise.

This problem becomes even more annoying when you are trying to track down an elusive bug in a compiled program. An interpreter will let you insert STOP and PRINT statements at crucial places in the program; you can even patch in a GOTO to skip over a given section of the listing. It is easy to start a program from a point in the middle, perhaps using variables set up earlier but as most compilers generate pure machine code (without line numbers or comments), they rarely permit interruptions of this kind and each and every temporary change must be compiled with the whole program. As a compilation usually takes minutes rather than seconds, the speed improvement offered by a compiler begins to look slightly less attractive to the programmer.

Which To Choose?

So far we have made no mention of the relative sizes of compiled and interpreted programs. The main advantage of a compiler is that once it has done its job, it can be removed from memory as the compiled program is self-supporting machine code. An interpreter must be resident with your program when you type RUN (really the ***interpreter*** does the RUNning!). In practice quite a few routines used by an interpreter must be duplicated inside a compiled program — for example, code to handle arithmetic, read from the keyboard or write to the screen. Generally a compiled program will take up slightly less space than an interpreted one with its interpreter but the difference is not great. Many micros have their interpreters in ROM so that the space occupied cannot be used by a compiler anyway.

There are currently BASIC compilers available for many popular micros; at least five for TRS 80 and Video Genie, four for the PET and a couple for the Apple II. Most of these products have been released quite recently and compilers certainly seem to be 'the shape of things to come' in the future micro market. Next month we will look at one of the commercially-available programs — the ACCEL compiler for TRS80 and Video Genie. That investigation will illustrate many of the points to be considered by a user setting out to write a compiler (by no means an impossible task!) as well as some details of the operation of the program. If you'd like to speed up your computer's BASIC by a factor of ten times or more, check us out next month.

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The outside world is very different. Physical values vary smoothly over a frightening range — from the barely detectable minimum to a devastating maximum. Sound, for example, can change from a mere whisper to the thunder of a full symphony orchestra; voltages range from picovolts to thousands of megavolts; pressures vary from the touch of an ant's foot to the fury of a hydrogen bomb at ground zero. In short, the world is full of variations ....it is ANALOGUE in nature.

Matching To The Real World

Two problems present themselves. Firstly the real world must be matched to the computer input and secondly, the computer output must be matched to the real world. The 'real world' in practice turns out to be a small external system that must be SENSED in some way by the computer input and CONTROLLED in some way by the computer output. Figure 1 gives a simplified overview of the interface components.

The input transducer transforms non-electrical energy into electrical energy in much the same way that a photo-cell transforms the quantum energy of a light source into a voltage proportional to that light; a microphone transforms sound pressures into voltage; thermocouples transform heat energy into voltage and strain gauges transform the effects of stress into voltages.

Level adjusters are necessary to boost the output of the transducer if it is too small or, in some cases, reduce the output if it is too large to energise the Analogue to Digital converter. It behaves in general as a 'scaling ' device and in practice could take the form of a simple voltage divider network (if the purpose is to ***reduce*** voltage) or some kind of amplifier (to ***increase*** the voltage level). Although the term 'voltage' has been used to describe the input transducer's output, it should not be taken too literally. The transducer output may not always deliver electrical energy as a 'voltage'. Some might exhibit a mere change of resistance across a pair of terminals or perhaps a minute change in current. It is the responsibility of the level adjuster to adjust the transducer 'output' into a voltage that is within the acceptable range demanded by the A/D converter input.

Another responsibility of the level adjuster (the term 'signal-conditioner' can be used as an alternative), is the question of the actual voltage ***level*** as distinct from the voltage ***range***. For example, a voltage range can be between 0 V to 5 V or from −1 V to +4 V ...they both have the same range but have different average levels. The level adjuster would often contain the calibration circuitry to compensate for production line variations in the transducing device and also the errors introduced by the level adjuster itself!

In the present state-of-art, the accuracy of the entire system rests almost entirely on the technical merits of the level adjuster; the transducer and A/D converters are established and proven 'black-boxes'...we just take them and the supplied data sheets for granted.

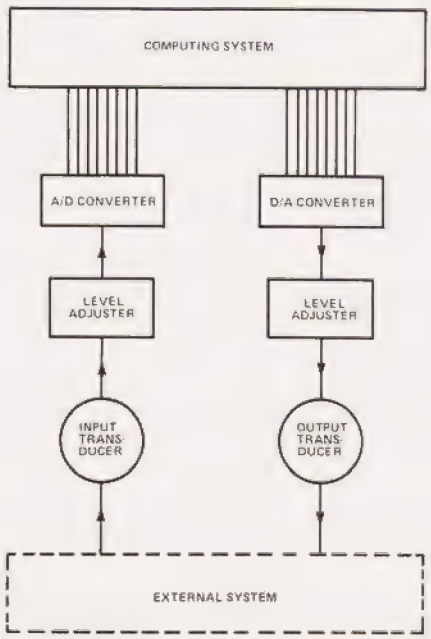

Fig. 1.
Matching components

The A/D converter has the responsibility of converting the analogue voltage from the level adjuster into a set of binary output voltages. Prior to their integration, these were constructed in discrete circuit form and full of weird gimmicks which went some way towards justifying their enormous expense. Fortunately for the system designer, all of the circuit complexity and interference worries associated with the numerous type variations have been replaced by the simple task of deciding which chip is the best (or cheapest!) for the particular project. Figure 2 shows a typical A/D converter.

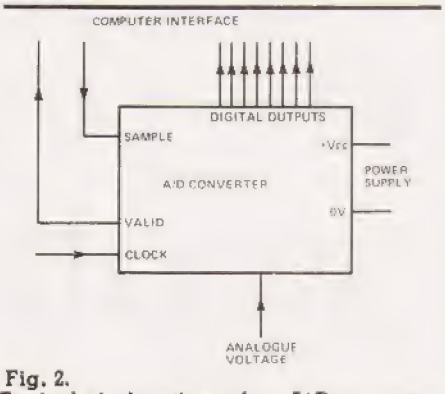

Fig. 2.
Typical pin functions of an A/D converter

A single pulse on the pin 'Sample' causes an internal counter to start up. When the count has reached a value equivalent to the analogue voltage input, the 'valid' pin changes state signalling to the computer that the digital output is now stable and may be entered into the computer's memory. The counter requires a clock input which can be a separate entity or pinched from the computer's private clock. The intestines of the contraption will be explained later although the information is, to some extent, only of curiosity value satisfying those who have been brought up in the belief that nothing should be used unless you fully understand it!

Terminology Explained

It is important to understand the significance of the terms used to describe the merits of an A/D converter chip. Unfortunately, a glance

at most data sheets issued by manufacturers causes a mixture of awe and gloom. There seems to be too much information, obscuring the item you want behind a forest of data you don't want (or don't understand). Here are some terms:

Number of digital outputs: The example of Fig. 2 is that of an eight-bit converter, a device that allows the analogue input voltage to be converted to an eight-bit binary 'word'. The number of combinations of n bits is 2^n so in this case we have 2^8 or 256 combinations ranging from 00000000 to 11111111 which is decimal zero to 255 inclusive. The **resolution** of the conversion is one part in 256 which in percentage terms is approximately 0.4%. Some actual figures may help to appreciate the scaling although it is unfortunate that round binary numbers don't seem to mix with round decimal numbers.

Assume analogue input voltage varies over the range 0 to 2.55 V. Since 2.55 V is the 'full-scale-deflection' and 255 is the maximum digital number, it follows that each binary bit count is worth 2.55/255 = 0.01 V (10 mV).

We can thus express the **scaling** of the A/D converter as **10 millivolts per bit.**

It is important to realise that the number of bits sets the limit on the smallest recognisable 'quantum jump' at the analogue input. When the input voltage slides smoothly say from zero to 4 mV, the digital output would probably still record zero (00000000). Somewhere on the voltage climb between 5 and 10 mV, the digital output would suddenly jerk to 000000001. Thus the **digital** conversion accuracy is on average, +/− half a bit, which in the example above equates to +/− 5 mV.

It should be evident that the number of bits in the ultimate parameter which decides the delicacy of conversion. For example, suppose we had a 12-bit converter. The digital range is then 000000000000 to 111111111111 or zero to 4095 decimal. Using 2.55 V as before to represent full scale this would yield a scaling of 0.6 mV per bit (approximately).

The cost of A/D converters goes up with the numbers of bits because of the increasing accuracy required from the internal circuitry. For the vast majority of work, eight-bits are ample, 12 are nice but 14 bits (which is approaching the present state of art) would in most cases be a disgraceful extravagance. Remember that the old adage regarding the 'weakest link in the chain' applies here as well.

The input voltage range: An input voltage too high or of the wrong polarity can cause damage so it is vital to observe this figure on the data sheets. However, unless otherwise stated, most chips are designed to be TTL compatible which fixes the highest voltage at 5 V on any pin. This precaution is the responsibility of the preceeding level adjuster.

Conversion time: This is the time it takes for the digital output to count up to the correct analogue voltage equivalent. Apart from negligible delays within the converter, this is dependant on the frequency of the internal clock shown in Fig. 2. For simplicity we will assume the clock is exactly 1 MHz, one pulse per uS. Thus it will take an eight-bit converter 255 microseconds to count up from zero to maximum. Put another way, the worst case delay between the emission of the 'sample' and the detection of the 'valid' signal would be 255 microseconds.

The Other Way Round

This is functionally and internally simple in comparison with the D/A converter, see Fig. 3. For one thing, it doesn't require a clock. Previous remarks regarding resolution still apply but the conversion time is irrelevant because the analogue output follows the digital input (almost) instantaneously.

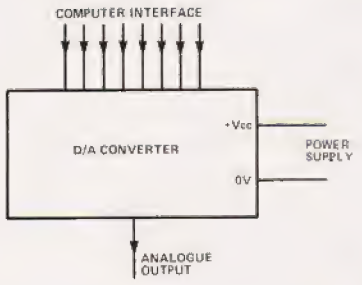

Fig. 3.
Typical pin functions of a D/A converter

The output transducer: (Refer to Fig. 1 again.) This is the reverse function. It accepts an analogue signal and converts it to a proportional physical quantity. It would not always be required since in some cases, the system would be content with the voltage as it stands. Some examples of output transducers are loudspeakers, electric motors and cathode ray tubes.

Summary

An input transducer **senses** a change in a physical quantity. The input level adjuster accepts the electrical output of the transducer and, according to the demands of the A/D converter, **amplifies** or **attenuates** the voltage. It may also change the actual DC **level** or polarity.

The A/D converter accepts the analogue voltage from the level adjuster and converts it to a **proportional** set of binary bits.

The **resolution** of conversion is a function of the number of binary bits, the smallest detectable analogue change being equal to $\frac{1}{2}^n$, where n is the number of bits.

The **conversion time** of an A/D converter depends on the input clock frequency and should always be interpreted on the worst-case change.

A D/A converter accepts digital inputs and converts them to a proportional analogue voltage. It does this almost instantaneously and requires no clock.

Most converters available are TTL cpmpatible. They either expect TTL digital inputs or deliver digital TTL outputs. The details of the 'TTL' protocol are as follows.

Logic '1' (called a HIGH level) is between +2.4 and +5 V.
Logic '0' (called a LOW level) is between 0.0 and +0.4 V.
(Any voltage resting between the above limits would give undefinable results)

It takes 40 uA to correctly energise a standard TTL input to the HIGH stage and 1.6 mA to energise it to the LOW state (called 'source' and 'sink' currents respectively).

Next Month

So far we've only investigated how we can get *one* signal into the computer and *one* signal out. Obviously for control applications we will need to deal with a large number of input and output transducers. In order to deal with all these connections without having to have an A to D and a D to A for each we can use a sophisticated electronic switching system and this is what I'll be taking a look at next month.

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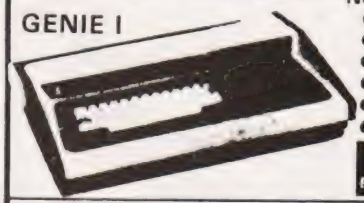

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16-BIT STAKEOUT

Peter Freebrey

This is the third variant of the TI Personal Computer to reach the UK in as many years. Is it still a viable system for home use?

The Texas Instrument's 99/4A had, I'm afraid, slipped my attention until quite recently. There does not seem to have been the pressure advertising that one would have expected for such a machine and the software and accessories at present available for it.

The TI has been subject to a pretty massive price reduction in the past year and at its present cost of around £299, it would appear to be well worth considering. There is no doubt which sector of the market that the TI 99/4A is being aimed at — the all-in-one computer for the home environment. It has facilities for the accessories that we have come to expect with this sort of machine . . . joystick controls, plug-in modules, etc, and is intended for use with your colour television.

The TI 99/4A comes complete with a separate UHF modulator pre-tuned to channel 36 and a separate power supply unit. The power supply unit and modulator have acceptably long leads to enable you to sit at a comfortable distance from the TV — rather different from some set-ups requiring you to crouch uncomfortably close to the screen. The modulator has a very short lead for the UHF output, sensible from an electronic point of view but could pose problems with free-standing television sets. For instance, how do you balance this not particularly light box near the set? Certainly you must not let it hang in mid air . . . must you? In fact these 'little boxes' bring in my first criticism of the Texas system. I am a firm supporter of modular systems but I feel that Texas have carried this a little too far. Should you become the proud owner of the TI 99/4A and its associated printer and disc drive (they call it disk . . . you'd think the Americans would have learnt to speak English by now!) you will have in front of you six separate units . . . eight, if you include the Voice Synthesiser and the television.

Although I can appreciate the reasons behind this procedure, I would welcome a reduction in the number of units. Some, it is true, plug directly into one another — the Voice Synthesiser plugs into the right-hand side of the computer and the Disc Controller can plug into either that same socket or one on the side of the Synthesiser. The RS232 interface and printer can be treated in exactly the same way.

Putting It All Together

Now, let us look at what we have got and see what we can do with it. The keyboard unit is neat and straightforward with a standard QWERTY-type layout, the numerals positioned on the top row of keys. I prefer a separate numeric keypad but this is purely a matter of personal preference and one quickly becomes familiar with whatever system is provided. Just a few hours of key-bashing and size, position and dual function keys soon slot into your subconscious. The keyboard is a little smaller than some but perfectly easy to use, even by someone with fingers as clumsy as mine. On the review model, two or three keys were a little sticky and although they had fully returned to their rest position before I got to pressing the next key, it did leave a nagging worry as to whether one day they would stay down!

Good quality sockets are used to connect to the power supply, modulator, tape recorder and remote controls (joysticks, etc). The sockets for tape recorder and remote controls are the same type and size and, although I'm sure Texas will have protected the appropriate circuits, it surely would have been more sensible to use a different type. Neither are the sockets labelled in any way and, bearing in mind that this is aimed at family use, I think some form of unique connectors should be the rule.

Did someone mention instructions? Home computers are notorious for their poor instructions/manuals but here Texas have produced something definitely in the superior bracket. The machine comes complete with two manuals . . . Beginner's BASIC and the User's Reference Guide. Beginner's BASIC is A4 size, has 140 pages and is essentially a Beginner's 'hands-on guide' to programming in TI BASIC. The approach is clear, easily understood and progresses

through the more simple routines in a fairly rational manner.

The programmer starts off using the TI 99/4A in the Immediate Mode and is first introduced to 'Simple Programming' using less than ten commands/statements. This is followed by a longish chapter on 'More Programming Power' which brings in more BASIC commands/statements. Sections on improved displays of PRINTed material and an introduction to the arithmetic power of the computer, complete the instruction phase. Early use is made of the colour and sound functions and how to produce them. This is perhaps not the way a computer buff would proceed but, in this case, it provides an interesting approach that is both entertaining and instructional. In fact, it will probably encourage more interest in computer programming than the drier factual approach often seen in the past.

The User's Reference Manual (A4, 170 pages) starts with Section I 'GENERAL INFORMATION' explaining clearly and with a number of diagrams what you should have to do to get the system up and running: how to interconnect the various units, what additional accessories are available and, most important of all, a brief explanation of keyboard and special function key operation.

The special function keys have a further short section to themselves amplifying the previous information. These keys: FCTN and CTRL are used as special SHIFT keys giving such operations as cursor control, INSERT and DELETE character and ERASE line. Entering control characters (CTRL key) also enables the TI 99/4A to link in with various telecommunications devices.

Section II entitled 'BASIC REFERENCE SECTION' takes the reader through such basics as numeric constants, variables, string expressions, reserved words, etc to a complete listing of all the TI BASIC words understood by the TI 99/4A. These are grouped together under sub-headings such as 'Commands', 'General Program Statements', 'Colour Graphics and Sound', 'Built-in String Functions', etc. Each TI BASIC expression/word is explained clearly with plenty of examples to hammer the point home.

Section III, 'APPENDIX TO BASIC REFERENCE SECTION' contains such items as ASCII character codes, keyboard mapping, colour codes, error messages and some applications programs.

Right: The TI and its companion power supply. The Command Modules plug into the slot at the right of the keyboard.

Below: The main expansion connector for driving the various peripherals.

There are eight further short sections; one worthy of mention is a fairly comprehensive index providing such information as a glossary, how to use pre-recorded software, various addenda, very simple fault finding (eg have you plugged into a mains outlet?) and the UK guarantee!

Up And Running

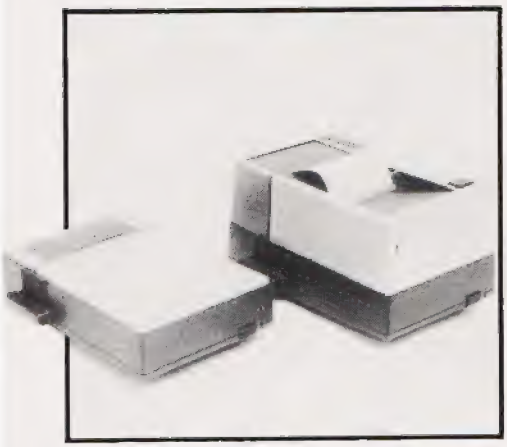
After connecting up and switching on I must admit to being quite impressed with the display. The initial display consisted of a number of coloured rectangles together with the Texas Instruments' Trademark (logo) and the words: HOME COMPUTER READY, PRESS ANY KEY TO BEGIN. The colours were stable with only a small amount of colour fringing and, unlike some experiences with other computers, gave the impression of a steady business-like display. On pressing 'ANY KEY' you are presented with a menu:

```
  PRESS
1 FOR TI BASIC
```

Should you have any of the TI software plugged in, the menu will of course be extended to include the options available. The 'plug-ins' are called 'command modules' and are plugged in by sliding the cartridge machine in the recessed tray at the right of the keyboard. Command modules should only be inserted or removed when the machine is in its initial quiescent/waiting mode of 'PRESS ANY KEY TO BEGIN' (known as the 'master computer title screen'). You may return to this mode at any time by pressing the FCTN and '=' keys simultaneously or by entering BYE. The latter is recommended as it first CLOSEs all OPEN files then erases all programs and variables in the memory, finally resetting the computer ready to return it to BASIC when required. The 'FCTN =' (QUIT) command does not CLOSE any files but is used when you have a command module in operation and no opportunity to type BYE (most of the keyboard is disabled for many of the games).

Having pressed 1 for TI BASIC we get a light blue screen with black letters saying TI BASIC READY and in the bottom left corner a prompt character (>) followed by a flashing cursor (■). The full screen display area of 32 characters across by 24 high may only be used by graphic symbols and an area of 28 x 23 can be used for PRINT statements or LISTings. Any program line may be up to four screen lines in length (112 characters including the line number). The computer is fairly

Above: The rear of the TI showing the cassette and video outputs.



Above: The thermal printer and the RS232 interface.

user friendly although it does demand spaces in the right places;

```
20PRINTA
20 PRINTA
LIST30
EDIT40
```

are all unacceptable whereas

```
20 PRINT A
LIST 30
EDIT 40
```

are acceptable statements.

It will display a number of ERROR messages should you ask it to do something unacceptable. Certain errors are detected on entering a command or program line; entering LIST100 gives the message INCORRECT STATEMENT as there is no space between LIST and 100 and entering an EDITed line that exceeds the memory capacity gives the message MEMORY FULL.

The computer will accept program lines that are incorrectly written and ENTERed but when you RUN the program, it will come to a dramatic halt (crash) on reaching the line. These errors may be detected in two ways. First, on RUNning the program but before the program lines are actioned, the computer scans the program in order to establish a 'symbol table'. This is an area of memory where the variables, arrays, functions, etc are stored. If the computer detects an error during this 'scan' it will display an ERROR message, eg FOR-NEXT ERROR, telling you that the program has a mismatched number of FOR-NEXT statements. While displaying this message the screen remains in its 'programming mode' colour of light blue. Should this 'memory scan' prove acceptable the program is then RUN and the screen becomes a light green colour while the program is RUNning. During the program RUN, PRINT statements, etc are displayed as black letters on the same green screen, unless programmed for a different combination. At this point the computer has accepted the scan but, in the process of RUNning the program, further errors can still cause a crash. The screen then reverts to light blue and an ERROR MESSAGE along with the line number at which the crash occurred will be displayed. For example;

BAD LINE NUMBER IN LINE 320

indicates that a jump was made to a non existent line in the program.

If you have used many other microcomputers you cannot help but notice that the TI 99/4A appears to be a little slow.

```
10 FOR I = 1 TO 1000
20 NEXT I
```

takes 3.3 seconds. If we add

```
15 X = A + B
```

the micro takes 8.76 seconds. This is a pretty crude way of testing a computer's relative speed of operation but it does give one some idea. Nowadays, a lot of stress is put on the speed a computer will work at. Of course, this is important, but what are you going to use this computer for? A dedicated scientific computer to work out formulae containing hundreds of steps.... I doubt it. The TI 99/4A *is slower* than a number of machines on the market today but for the vast majority of uses it will be put to, I doubt that the users will mind too much.

TI BASIC has a number of commands/statements that some machines do not have and one or two that are not in its vocabulary. I was pleased to find:
RESEQUENCE renumbers program lines;
TRACE lists the program line number as it actions that line;
NUMBER gives you automatic line numbers when writing a program as well as ON....GOTO and IF...THEN...ELSE which are not always present in micro BASICs.

The string handling capabilities seem to be quite reasonable and the arithmetic functions all that one normally expects. A slightly unusual array handling command is OPTION BASE allowing you to set the lower limit of an array to either 0 or 1. This can be quite useful to those of us who get confused dealing with complicated array handling while trying to remember that the 15th element in an array is represented by A(14) and not A(15)! OPTION BASE is definitely the easy way out!

Missing from what is otherwise a pretty comprehensive line-up of commands/statements are PEEK and POKE. This is nowhere near as desperate as some people make out because users of this machine would probably not be wanting to delve into memory locations. However, for those of you who may wish to interrogate the display screen TI BASIC presents us with CALL HCHAR, CAL VCHAR and CALL GCHAR of which more shortly.

To clear/erase the screen, whether in immediate or program mode, the CALL CLEAR command (TI BASIC calls is a sub-program) is used. CALL in TI BASIC can be followed by a number of keywords:

CALL CHAR Allows you to define your own special graphics characters. You may redefine the standard set of characters with codes 128-159. The characters are made up of up to 64 dots in an 8 by 8 grid allowing a varied set of special charaters to be used...memory permitting.

CALL HCHAR Allows you to display on the screen a specified character at a specified location (defined by row and column) and will repeat that character horizontally for a specified number of times.

CALL VCHAR Similar to HCHAR, VCHAR repeats the character vertically rather than horizontally.

CALL SCREEN Defines the screen colour on which individually coloured cells are displayed (**CALL COLOR** then defines the foreground and background colours of that cell).

CALL SOUND Allows you to generate a tone between 110 Hz and 44,000 Hz. You may define the dura-

tion in milliseconds and the volume on a scale of 1 to 30. Further, you may generate up to three tones plus one noise to be played for the same duration at the same time (ie three note chords, etc) all with their own specified volume levels! You also have the option of various 'white noise' effects.

CALL GCHAR Allows you to read a character from the screen, the location required being specified by row number and column number.

CALL KEY Allows you to transfer one character from the keyboard directly into your program. It is similar to other BASIC's GET or INKEY but is slightly more sophisticated as certain keys may be disabled if required.

CALL JOYST Allows the input of information based on the position of joystick/lever on the Wired Remote Controllers that are an accessory for the TI 99/4A.

The TI 99/4A will allow assignment in both the now somewhat obsolete LET A = n or in the more common form of A = n. In which case why bother to type in those extra letters? The TI 99/4A has 16 K of user RAM expandable to 32 K using plug-ins, however this is only accessible to an appropriate command module or accessory if in circuit.

Plug Into Programs

A number of plug-in command modules are available ranging through various games, a number of educational titles and a Speech Editor to a Disc Manager and TI Extended BASIC.

The games include the inevitable 'TI Invaders' and various other 'shooting games' set in different scenarios. All offer more than one difficulty rating and all start at a 'difficulty rating' high enough to make them interesting and reasonably addictive.

'Carwars' is simply two cars in plan view racing around concentric tracks, one car 'eating up' a series of dots as it goes. You may change tracks at North, South, East and West and the second car is programmed for a head-on collision . . . you have to avoid it! A very simple game but requiring quick reactions and very definitely addictive.

'Hunt the WUMPUS' is a game of logic to find in which cavern the Wumpus is hiding. You get clues as you explore the caverns . . . . it isn't difficult but the Wumpus seems to eat up its opponents all too often! Good fun and it certainly makes impetuous youngsters think ahead.

'Video Chess' has good graphics and although it sometimes plays some very strange moves you cannot afford to take it lightly. You may choose its type of play . . . aggressive, normal or defensive and the level of play. A good club player should be able to beat it but may get the occasional surprise.

'Connect Four' is a real brain-teaser and like several of the other games may be played by either one person against the computer or as a two-player game. Against the computer you have several levels of difficulty and I enjoyed it immensely. My only criticism is that of its psychological oneupmanship . . . . when you place a 'token' on the grid it sounds a minor 'ker thonk' but everytime *it* places a token you get a little tune that gives the impression of 'rah, rah, rah . . . so there, beat that!' An excellent game.

The 'Speech Editor' is fun but although its vocabulary is quite large (more than 300 words) I'm afraid I found this the least interesting of the 'plug-ins'. The words are clear (with American accent) and it is possible to build words from those already built-in, but I found that whenever I wanted a special word it was not possible to make it up . . . . obviously I am a visual rather than audio-oriented person.

The child education tapes are rather repetitive to a 'grown-up' but delight the little ones especially when they get a gold star and some stirring music when they solve their problem. These cover Pre-School Early Learning, Early Reading, Beginning Grammar and Arithmetic.

'Household Money Management' is quite involved, with many questions regarding how much you earn and where it all goes. It takes some time to set up accurately, which of course you must do if you wish to take full advantage of its capabilities. It is a little depressing as, although I know I only have about £1 at the end of the month, I'm not so sure I want to see it boldly stated on the screen. Also, I'm not so sure it wouldn't be quicker to work it out on the back of an envelope!

The 'Disc Manager' enables you to use the TI Disc Drive via the Disc Controller and in the brief time I used it, it seemed to function perfectly. It is a little noisy in operation and when it read my first disc I had visions of the floppy being shredded, but nothing untoward has happened so far.

TI Extended BASIC offers a number of additional commands/statements and facilities that make it a very useful extra. Multi-statement lines are allowed which make life a little simpler when writing a program. It has an interesting command called CALL SPRITE, this enables you to create moving graphics very simply. This module also has a PEEK sub-program which, with other commands, allows access to assembly language sub-programs (of little interest to the intial buyer of the TI 99/4A but could be of great value as his/her computer awareness grows).

In all there are more than 40 new or expanded commands in TI Extended BASIC and although the standard TI BASIC is quite comprehensive, this module will certainly open up new horizons for the addict.

The TI 99/4A may be used with a tape recorder to SAVE your programs or data on cassette tape. Texas Instruments recommend two inexpensive, readily available tape recorders for this purpose. They are the PYE 9110 and the SANYO Slimline both available for around £20.

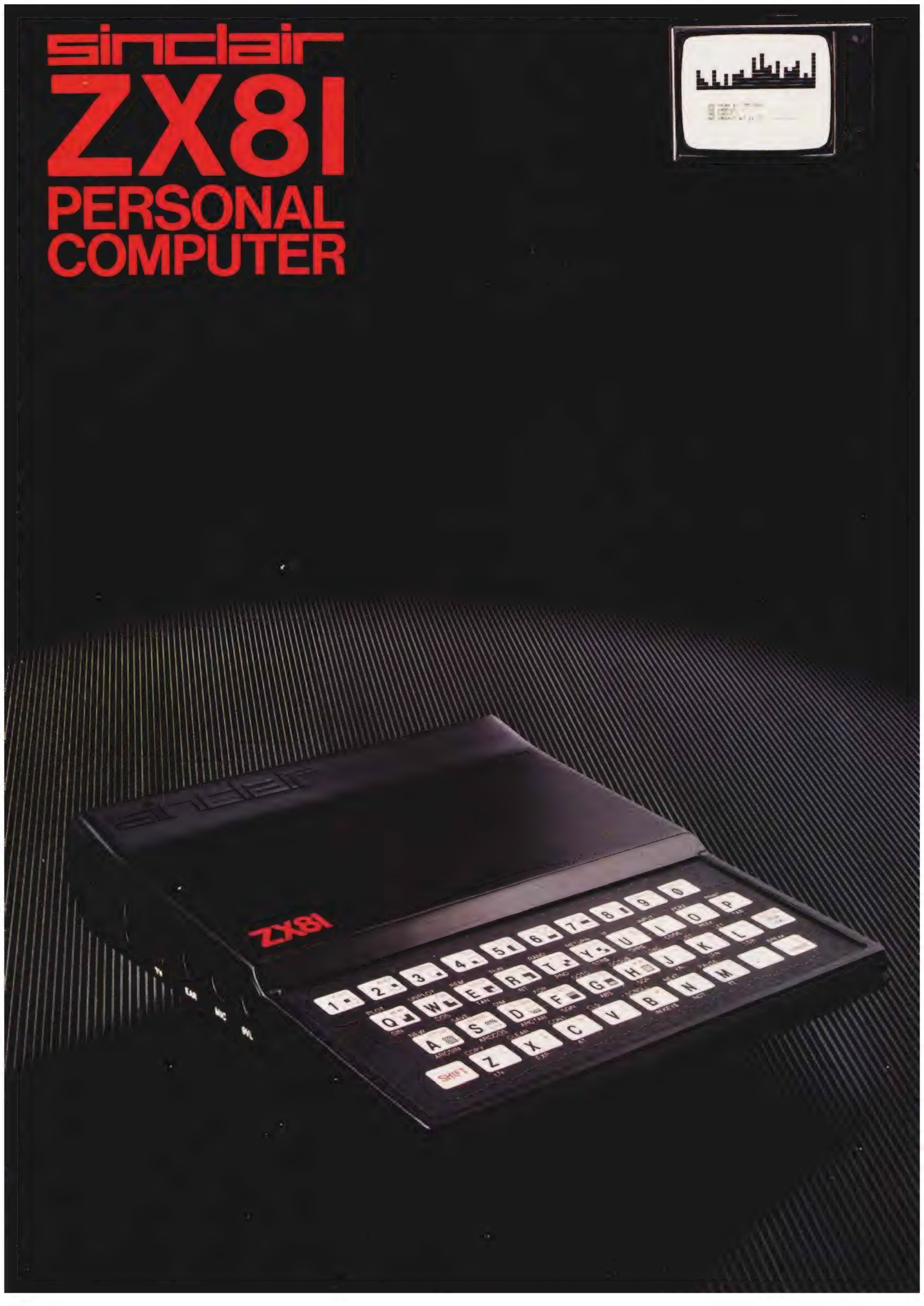
The TI Solid State Thermal Printer may be plugged in directly to the computer and uses a narrower than usual paper which will accept 32 characters per line. Unfortunately, the review model could not be persuaded to print anything at all. As this was sent to us only a day or so before this report was due we have not had the opportunity to let Texas Instruments comment upon this failure.

Overall Opinion

In conclusion I can only say that I have enjoyed having the TI 99/4A in my home; my children, aged six and 7 years old, have enjoyed both the games and the educational modules. Although the younger child could cope rather easily with all but the grammar module, it has been educational to see just how the use of the computer can hold the interest and in turn make young children aware of computers.

I could find no single major fault with the TI 99/4A but that it might flounder as a complete system. As a home entertainment unit that can also be used as a comprehensive computer it is fine, but I feel that overall, people will think twice before purchasing a complete system.

sinclair ZX81 PERSONAL COMPUTER



Sinclair ZX81 Personal Comp the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

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With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

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Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

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The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

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Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

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EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

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	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
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	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
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ZX81

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How the ZX81 compares with other personal computers

SYSTEM IDENTIFICATION		ZX81	ZX80	ACORN ATOM	APPLE II PLUS	PET 2001	TRS 80 LEVEL I	TRS 80 LEVEL II
ROM		8K	4K	8K	8K	14K	4K	12K
GUIDE PRICE	Basic unit – inc. VAT Unit plus 16K RAM (*12K RAM)	£70 £120	£100 £150	£175 £285*	£630 £630	£435 £530	£290 £360	£375 £375
COMMANDS	LIST, LOAD, NEW, RUN, SAVE	●	●	●	●	●	●	●
STATEMENTS	PRINT, INPUT, LET, GOTO, GOSUB/RETURN, FOR/NEXT IF/THEN	●	●	●	●	●	●	●
	STEP	●		●	●	●	●	●
	TAB	●			●	●	●	●
ARITHMETIC	ABS, RND	●	●	●	●	●	●	●
FUNCTIONS	INT	●			●	●	●	●
	ATN, COS, EXP, LOG, SGN, SIN, SQR, TAN	●			●	●		●
	ARCSIN, ARCOS	●						
STRING	CHR$	●	●		●	●		●
FUNCTIONS	LEN	●		●	●	●		●
	ASC(CODE), STR$, VAL, INKEY$	●				●		●
NUMBERS	FLOATING PT $\pm 10^{\pm 38}$	●			●	●	●	●
	INTEGERS		●	●	●	●		●
NUMERIC	A-Z			●			●	
VARIABLES	AA-ZØ				●	●		●
	An-Zn, n = any alphanumeric string	●	●					
STRING	A$ & B$						●	
VARIABLES	A$ to Z$	●	●	●				
	An$ to Zn$ n = any alphanumeric character				●	●		●
NUMERIC	SINGLE DIMENSIONAL		●	●			●	
ARRAYS	MULTI DIMENSIONAL	●			●	●		●
DISPLAY	ROWS	24	24	16	24	25	16	16
	COLUMNS	32	32	32	40	40	64	64
	LOW RES GRAPHICS (<7000 pixels)	●	●	●	●	●	●	●
	HI RES GRAPHICS (>40000 pixels)			●	●			
SPECIAL	USR (CALL, LINK)	●	●	●	●	●		●
FEATURES	PEEK, POKE (OR EQUIV)	●	●	●	●	●		●

Sinclair software on cassette.

The unprecedented popularity of the ZX Series of Sinclair Personal Computers has generated a large volume of programs written by users.

Sinclair has undertaken to publish the most elegant of these on pre-recorded cassettes. Each program is carefully vetted for interest and quality, and then grouped with others to form single-subject cassettes.

Software currently available includes games, junior education, and business/household management systems. You'll receive a Sinclair ZX Software catalogue with your ZX81 – or see our separate advertisement in this magazine.

The ultimate course in ZX81 BASIC programming.

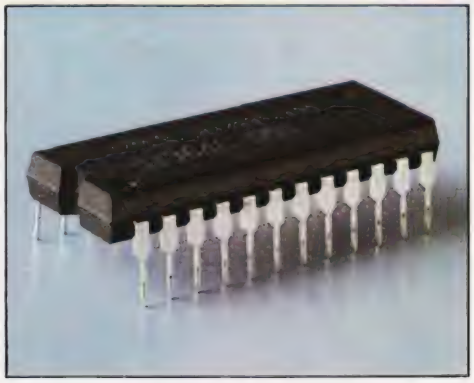
Some people prefer to learn their programming from books. For them, the ZX81 BASIC manual is ideal.

But many have expressed a preference to learn *on* the machine, *through* the machine. Hence the new cassette-based ZX81 Learning Lab.

The package comprises a 160-page manual and 8 cassettes. 20 programs, each demonstrating a particular aspect of ZX81 programming, are spread over 6 of the cassettes. The other two are blank practice cassettes.

Full details with your Sinclair ZX81.

If you own a Sinclair ZX80...



The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 – including the ability to drive the Sinclair ZX Printer.

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ZX81

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Peter Freebrey

FIRST BYTES

Can computer programs make decisions for you? IF you give them the right command THEN they can!

This month we take you one step further and, if I may completely butcher a well-known quote, 'one small step for the computer but a giant stride for the programmer'; the step referred to is the use of the BASIC statement IF... THEN. This, more than any other command/statement, opens up possibilities for the programmer only previously dreamed about! It enables you to program your computer to take decisions and then act according to the decision taken. IF...THEN is also referred to as conditional branching. It is rather like walking down a road until you come to a fork; you may go either left or right. What determines your decision? IF there is a fire breathing dragon strolling towards you on the left hand path THEN you are going to take the right hand path unless, of course, you happen to be wearing your asbestos suit today! In other words you have a choice, and the relevant condition or conditions determine your future action.

In Operation

If you cast your mind back to the first FIRST BYTES we briefly mentioned operators... + − / * > < > = < =, the first four are used in arithmetical calculations, the = is used both to assign a value to a variable with the conditional operators to instruct the program whether a 'dragon' is round the next corner or not! Let us look at how these conditional operators may be used:

```
IF X = Y THEN 200
IF X is equal to Y THEN GOTO line 200
IF X > Y THEN 200
IF X is greater than Y THEN GOTO line 200
IF X < Y THEN 200
IF X is less than Y THEN GOTO line 200
IF X >= Y THEN 200
IF X is greater than or equal to Y THEN
GOTO line 200
IF X <= Y THEN 200
IF X is less than or equal to Y THEN GOTO
line 200
IF X <> Y THEN 200
IF X is not equal to Y THEN GOTO line 200
```

Each of the above sets a condition IF X = Y, IF X > Y, etc. If this condition is 'true', the program will execute what is to the right of THEN. If the condition is not true then the execution of the program will pass to the next line in the program.

The following example simply prints the square root of a specified number, the IF...THEN statement checks to see that the number is valid, ie not negative.

```
10  INPUT X
20  IF X<0 THEN 10
30  PRINT X^0.5
40  END
```

If the number is negative, the condition set in line 20 is true and program execution is directed back to line 10 where a new number is requested. If the number is not negative, that portion of line 20 to the right of THEN is ***not*** actioned and the program continues to line 30. All computers will accept a line number following THEN, some will also accept other statements. The example above may then be written:

```
10  INPUT X
20  IF X>0 THEN PRINT X^0.5
30  GOTO 10
40  END
```

With this version, once it is RUN, the computer is in an endless loop as whatever number is INPUT, line 30 will direct program execution back to line 10. An infinite number of square roots may then be calculated with only the number X being keyed in! To break this loop you will have to key in BREAK or ESCAPE although some computers will break out of a loop if RETURN is keyed when an INPUT is requested ... some politely inform you that you have pressed the wrong key and continue to request an INPUT! Care must always be taken when using GOTOs; 1) they can lead all to easily to infinite loops and 2) they can lead to sloppy programming; there is nothing wrong with using GOTO but always look carefully to see if your program may be rearranged to eliminate its use.

A Practical Problem

The following example shows how the computer will take decisions and act on that decision until a certain set of circumstances defined within the program tell it to stop. The routine is a very crude attempt at solving a simple equation:

```
10  PRINT "SOLUTION OF X^2-A*X-A=0"
20  INPUT "WHERE A IS +VE =";A
30  X=0.1
40  Y=X^2-A*X-A
50  IF X>=0 THEN 80
60  X=X+0.01
70  GOTO 40
80  PRINT "MY BEST SOLUTION IS"
90  PRINT "X=";X;" WHERE X^2-";A;
    "*X-";A;"=";Y
100 END
```

Although this program would win no prizes for solving the equation given, it does demonstrate how the computer can be programmed to find a solution to a problem and if that solution is not the best it can manage, it will alter the parameters and try again. Lines 30 and 50 determine the limits of the computer's solution; line 30 says that the smallest value of X is to be 0.1 and line 50 says that if Y is greater than or equal to zero, the computer must display its current solution for X. Assuming the initial value of X is smaller than the required result, it then works out the value of the equation for this initial value (0.1). If the result is less than zero then line 60 adds a small increment (0.01) to the value of X and the execution of the program is returned to line 40. The program continues within this loop until the conditions set in line 50 are satisfied; at which point the computer's result is displayed. The value of Y is displayed to give an indication of how accurate the result for X has been.

A point to note is that, although many of these examples call for an INPUT of one or more numbers, in practice these routines or others like them would be part of a much larger program — the variables having been determined by some earlier part of the program.

Twin Tests

Often more than one test has to be performed to solve a particular problem. The following routine will tell you which of two numbers is the largest and by what percentage:

```
10  INPUT "X= ";X
20  INPUT "Y= ";Y
30  IF X=Y THEN PRINT "X=Y":END
40  IF X>Y THEN A=X/Y:Z$="X":
    GOTO 60
50  A=Y/X:Z$="Y"
60  PRINT Z$;" IS GREATER BY ";
    A*100-100;" PERCENT"
70  END
```

This routine assumes that the computer can accept multiple statements on one program line (the colon : separates the statements); if this were not the case then the routine would look like this from line 30:

```
30  IF X=Y THEN 120
40  IF X>Y THEN 80
50  A=Y/X
60  Z$="Y"
70  GOTO 100
80  A=X/Y
90  Z$="X"
```

```
100  PRINT Z$;" IS GREATER BY ;
     A*100-100;" PERCENT"
110  END
120  PRINT "X=Y"
130  END
```

There is no need to test whether Y is greater than X because this must be the case if the conditions set in lines 30 and 40 are not satisfied. Z$ and A are assigned to enable us to utilise a single PRINT statement and eliminate the GOTOs which would otherwise be needed. Line 30 has what,in other circumstances, could be a dangerous condition, ie IF X = Y. Be very careful in using the condition '=', in performing some calculations the computer may very well produce a result of 5.999999999 instead of the expected answer of 6. If you have a program line:

```
60  IF X=6 THEN 100
```

you might wonder why your program was taking so long in solving what you thought was a short simple operation...The fact is that it did solve it ages ago but because the exact condition X = 6 did not occur, it is still trying to please its operator by ploughing its way through the known universe trying to get there!

A much safer condition is:

```
60  IF X>=6 THEN 100
```

Stringing It Along

IF...THEN statements may also be used with string variables; both the following are acceptable:

```
70  IF X$="JOHN" THEN 150
70  IF X$=N$ THEN 150
```

You may wish to give the operator a choice, the choice being made by pressing a particular key:

```
100  PRINT "YOU ARE IN A DUNGEON"
110  PRINT "YOU MAY GO......."
120  PRINT "LEFT.....(L)"
130  PRINT "RIGHT....(R)"
140  PRINT "UP.......(U)"
150  PRINT "KEY IN YOUR CHOICE
     (L,R,U)"
160  INPUT X$
170  IF X$="R" THEN 100
180  IF X$<>"U" THEN 210
190  PRINT "YOU ARE IN A DARK HALL"
200  GOTO 110
210  PRINT "YOU WERE JUST EATEN BY A
     DRAGON"
220  END
```

Unfortunately, this little program is somewhat limited...you can only go round in circles or be eaten by the dragon!

Two other instruction words are often found in conjunction with IF...THEN statements. These are OR and AND; they qualify or add to the conditions set by an IF...THEN statement so:

```
60  IF A>B OR A>C THEN 100
60  IF A>B AND A<C THEN 200
```

Using OR, the instructions to the right of THEN will be actioned if either or both conditions are fulfilled. AND demands that both conditions are fulfilled. An example of the use of OR is given in line 50 of this routine to check whether a triangle is right-angled.

```
10  PRINT "ENTER THE LENGTHS IN
    WHOLE NUMBERS"
20  PRINT "OF THE SIDES OF THE
    TRIANGLE"
30  INPUT A,B,C
40  X=A^2:Y=B^2:Z=C^2
50  IF X+Y=Z OR X+Z=Y OR Y+Z=X THEN
    80
60  PRINT "THIS IS NOT A RIGHT
    ANGLED TRIANGLE"
70  END
80  PRINT "...THIS IS A RIGHT
    ANGLED TRIANGLE"
90  END
```

To get a computer to do some real 'thinking' and able to make decisions from its own programs, is one of the most important steps towards successful programming. The next is to make our programs fool-proof.

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Although primarily designed for the Sinclair ZX81, many of the cassettes are suitable for running on a Sinclair ZX80 – if fitted with a replacement 8K BASIC ROM.

Some of the more elaborate programs can be run only on a Sinclair ZX Personal Computer augmented by a 16K-byte add-on RAM pack.

This RAM pack and the replacement ROM are described below. And the description of each cassette makes it clear what hardware is required.

8K BASIC ROM

The 8K BASIC ROM used in the ZX81 is available to ZX80 owners as a drop-in replacement chip. With the exception of animated graphics, all the advanced features of the ZX81 are now available on a ZX80 – including the ability to run much of the Sinclair ZX Software.

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The 16K-byte RAM pack provides 16-times more memory in one complete module. Compatible with the ZX81 *and* the ZX80, it can be used for program storage or as a database.

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LIFE – J. H. Conway's 'Game of Life' has achieved tremendous popularity in the computing world. Study the life, death and evolution patterns of cells.

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GOLF – what's your handicap? It's a tricky course but you control the strength of your shots.

Cassette 2 – Junior Education: 7-11-year-olds

For ZX81 with 16K RAM pack

CRASH – simple addition – with the added attraction of a car crash if you get it wrong.

MULTIPLY – long multiplication with five levels of difficulty. If the answer's wrong – the solution is explained.

TRAIN – multiplication tests against the computer. The winner's train reaches the station first.

FRACTIONS – fractions explained at three levels of difficulty. A ten-question test completes the program.

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For ZX81 (and ZX80 with 8K BASIC ROM) and 16K RAM pack

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TWENTYONE – a dice version of Blackjack.

COMBAT – you're on a suicide space mission. You have only 12 missiles but the aliens have unlimited strength. Can you take 12 of them with you?

SUBSTRIKE – on patrol, your frigate detects a pack of 10 enemy subs. Can you depth-charge them before they torpedo you?

CODEBREAKER – the computer thinks of a 4-digit number which you have to guess in up to 10 tries. The logical approach is best!

MAYDAY – in answer to a distress call, you've narrowed down the search area to 343 cubic kilometers of deep space. Can you find the astronaut before his life-support system fails in 10 hours time?

Cassette 5 – Junior Education: 9-11-year-olds

For ZX81 (and ZX80 with 8K BASIC ROM)

MATHS – tests arithmetic with three levels of difficulty, and gives your score out of 10.

BALANCE – tests understanding of levers/fulcrum theory with a series of graphic examples.

VOLUMES – 'yes' or 'no' answers from the computer to a series of cube volume calculations.

AVERAGES – what's the average height of your class? The average shoe size of your family? The average pocket money of your friends? The computer plots a bar chart, and distinguishes MEAN from MEDIAN.

BASES – convert from decimal (base 10) to other bases of your choice in the range 2 to 9.

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A NEW FAD?

New languages seem to arise every month these days. Many are simply 'better' versions of old favourites, others completely fresh approaches to problems.

Despite its relatively recent launch in the USA the programming language FAD-T is soon to be made available in the UK. The language is primarily known by the name HI-CON after its application in high level control. Now renamed after its inventor, Thomas F Aldrick, the latest implementations have overcome many of the teething troubles associated with the use of a nine-bit word.

Overview

FAD-T is an interpreted language and is somewhat similar to BASIC in many of its structures. Table 1 gives a list of the standard FAD-T commands as defined by the 1980 Committee.

The self-interpreting code resides in some 8K of EPROM and it is essential that an EPROM programmer be wired into the system so that the source code can reprogram itself at run-time.

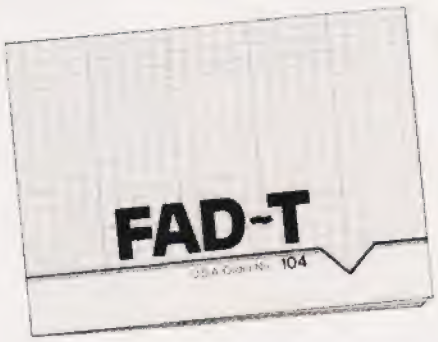
Each input line is scanned on entry and compiled into object code which resides in PROM rather than the more conventional RAM. This saves considerable development time for process control and similar systems because the testing processes and debugging can be performed on-line rather than having to produce complex simulations of the appropriate plant.

As in BASIC each line of code is preceded by a line number but only seven even numbers will be executed at run-time thus allowing copious space for comments. Unlike BASIC, these comments will not affect the running speed of the program because they are never accessed by the interpreter — they will however take memory space.

One of the most powerful standard features of the language is that all I/O can be directly memory mapped and there is virtually no restriction to the number of addresses that can be allocated to I/O devices. The following line of code shows a typical example of device allocation:

```
1 THIS IS A DEMONSTRATION
3 OUTPT X THIS IS A TEST
5 TERMINATE PROGRAM
40 END
```

Variables can be any length but only the first nine characters are significant and these must be alphabetic. The FAD-T command IS AT assigns the address to the variable. One other point worthy of note is that all numbers other than line numbers must be specified to base 9, the one remaining hangover to the days of the nine-bit processor systems. An upgrade to eight-bits is promised for the second half of this year. It is also hoped to include a floating point package rather than the current integer only.



Programming In FAD-T

Because of FAD-T's exceptional efficiency, programs must be entered very carefully and in order to ensure absolute accuracy, all lines of code must be entered twice.

Program storage is currently limited to tape using the DUMP and RESTORE commands but there is currently a small bug in the handling routine. Work is currently in progress to upgrade this to a major feature and when complete it will be included in the upgrade kit mentioned earlier.

A number of special enhancements have been made to the current version and among these are the extra commands listed in Table 2.

One interesting method of speeding up the task of program input offered on this version is that all commands can be abbreviated to their first letter followed by all the remaining vowels; tokenisation with a difference!

Coming Soon

Apart from the upgrade kit, a number of extensions to FAD-T are scheduled for 1982 and these included Rope Handling, Loofa Pril and Word Processing facility — the word to be processed has yet to be chosen.

Further information on the product can be obtained from the FAD-T Handbook by W E R Tyup published by Columbia Print and now a rather out of date article in the April issue of Computing Today.

RUN	Executes program.
WALK	Debugging aid that RUNs at 10th speed.
OUTPT	Prints the following literal missing any literals.
INPT	Accepts keyboard input.
GET	Reads from specified I/O port.
IS AT	Assigns I/O location.
PUT	Write to specified I/O port.
CALCULATE X	Assigns the result of the preceding formula to X. Note that the result must be used within 20 lines or it will be automatically deleted to save memory.
FORGET X	Randomly adjusts X.
GUESS X	As CALCULATE but much faster because it ignores the equation.
COME FROM XX, YY, ZZ	Similar to GOTO command found in BASIC but tags the lines from which the program jumped.
CORRUPT	Bombs the program out and simultaneously deletes all variables.

Table 1. The standard command set supplied with FAD-T.

IF	As in BASIC except that the command is terminated with ELSE DONT
GO BACKWARDS	Reverses the program flow.
WAIT nn	Waits for nn milliseconds.
WAIT IF	Waits on a condition.
RAND (X)	Returns a random number between 33 and 36.
ZERO (X)	Returns X when multiplied by zero. This avoids the DIVN BY ZERO error.
LOTS (X)	Adds three insignificant digits to X.
SAME (X)	Returns the previous value of X when more than 20 lines have been executed, see CALCULATE (X).
SQR (X)	Prints a square of X. eg SQR (4) = 4444 4444 4444
INT (X)	Returns the integer value of X.

Table 2. Extended command set offered with the UK version of FAD-T.

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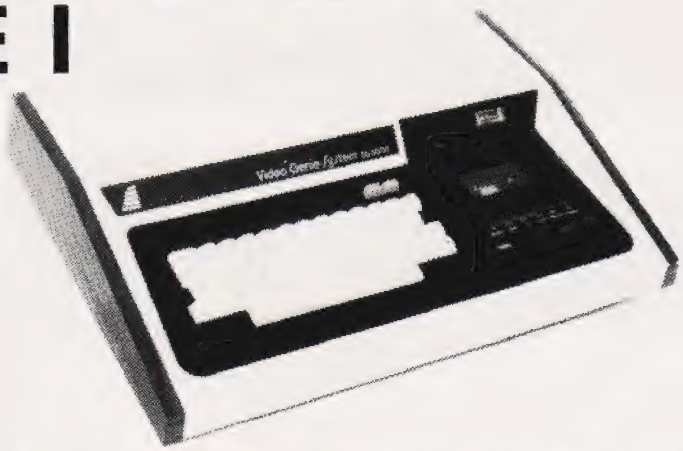

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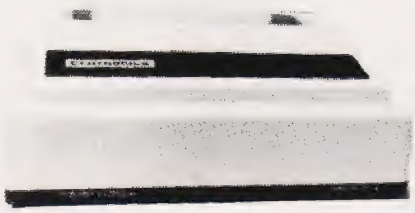

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THE VALLEY

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The news spread quickly throughout the lands of Tybollea. Vounim, mightiest wizard of the Northern Reaches, had arrived at the gates to the Princess Evanna's castle offering his aid against the Selric hordes which beseiged her realm.

Her magical powers alone too weak to vanquish the foes, Princess Evanna eagerly accepted Vounim to her side. Together forming a psychic bond they wove a spell, powerfully constructed from the forces of light and darkness, to drive the savages from Tybollean soil. Their combined magicks scoured the Northern border-lands, scattering the enemy's host and laying waste the Selric threat forever.

In gratitude, Princess Evanna invited Vounim to make his home in her Kingdom and bestowed upon him the title 'Lord of the Valley Between Two Castles'. Knowing the land between the Princess' castle and her brother Xeron's to be most beautiful country, Vounim accepted the honour and began plans to build two strongholds in the forests of the Valley.

Time passed... far away from the village settlements, Vounim's Lairs (as his strongholds had become known) were often the subjects of whispered conversation in the ale-houses of Tybollea. Even the Princess Evanna's councillors felt that the Princess had closed her eyes to the changes that had overtaken Vounim during the years he had attended the castle as her chief advisor. He had become quiet and withdrawn, only visiting the castle at the dead of night. It was even rumoured he had entertained in his strongholds members of the White Order, an evil brotherhood of wizards from the Southern Slopes.

Following just one of these visits from the White Order, Vounim had begun building two temples dedicated to the worship of an obscene lizard-like god, Y'Nagioth. Shrouded by evil swamps, it seemed as though none could stop the wizard from carrying out his ancient sacrificial rituals. At first, the Princess listened to the stories of livestock disappearing and of children running off with an air of humour; but soon even she could not deafen her ears to the allegations of the high taxes and cruelty of which her people complained. However, it was only when her war-like brother, Xeron, seemed to wither away in his sick-bed from the 'medicines' administered by Vounim that Princess Evanna began to see the threat posed to her throne.

Arranging a Council of War with her neighbouring Lords, Princess Evanna asked them to pledge their allegiance and grant her the aid she needed to crush the evil wizard. There was much brave talk and long discussion but eventually the Lords decided not to intervene. The worship of Y'Nagioth had spread and the peoples of Tybollea would likely as not support the wizard, High Priest of the lizard faith, rather than their over-lords.

The Lords quite clearly feared Vounim more than the Princess and rather than follow their heart's dictates chose the easy route. The Princess was disheartened and, clearing them from her Council Chamber, slumped into her throne deep in thought. She could destroy this wizard, she mused, but at what cost?

As dawn broke, the Princess' meditations were interrupted by a young wizard by the name of Alarian. She recognized him instantly as the novice attached to Baron Niitall, Lord of the Eastern Plains — one of the Lords she had expected would grant her the aid she would need. Although far below the Princess in magical prowess, Alarian was able to offer the wealth of his experiences as a youth apprenticed to the mighty Vounim back in the Northern Reaches. The young wizard also gave the Princess his copper amulet, studded with six precious gems — Alarian's amulet was a magical device, providing its wearer with the gift of life after mortal death.

Mounting her horse at the castle gates, Princess Evanna made one last desperate attempt to encourage her people to her side; the Lords looked away and her subjects jeered. So, muttering a curse, the Princess Evanna set off to face Vounim in his lair.

As she rode, she was saddened by the apparent sickness that hung over the Valley; nothing grew there now, save in the forests and swamps that surrounded Vounim's Lairs and the Temples of Y'Nagioth. Yet as she rode on she discovered, sheltered in the depths of the Valley floor, another building — a six-storey tower. She recognized the tower with sickening rapidity, she had

once seen it in her youth — it was a replica of the Black Tower of Zaexon, the home of the brotherhood of the White Order. Satisfying herself that the tower was empty, she spurred her mount and raced with renewed vigour towards the demon wizard, Vounim.

Catching the wizard amidst a ghastly blood rite, Princess Evanna began casting a spell of banishment on Vounim. Caught off guard, the Lord of the Valley, screaming vile obscenities, started to fade from sight. With a final blood-curdling scream, he made a final gesture at the Princess before passing from the mortal plane. The Princess, surrounded by dancing lights, fell to the floor writhing in pain. She had been poisoned by Vounim's magic and, with mounting horror, realised this would be a magical and not a mortal death — the Amulet of Alarian would not help the Princess to cheat her fate.

Crumpled on the floor of Vounim's Lair, the Princess began to make her last magicks. She hid the Amulet in one of the Temples of Y'Nagioth and three of the stones she placed on the third floor of the Black Tower of Zaexon, the fourth stone on the fourth floor, the fifth and the sixth stones cached on the two top floors. Struggling to keep her consciousness, the Princess made one last gesture at the Helm and as she died, her magick passed into the Helm as it disappeared from sight forever.

The Valley buildings disappeared soon after Vounim's banishment, following him into the ethereal limbo in which the Princess had imprisoned him. Gradually over the years, the Valley returned to its former splendour. Alarian, satisfied that Evanna's spell was well cast, remained there for many years keeping his eye over the Kingdom. Then one fine morning, the first of Spring, Alarian, leaving a spell of watchfulness over the land, left for other adventures.

Concluding the story, he turned his attention to the Valley lying far beneath his window, blanketed in swirling mists shrouding all but the highest tree tops. On the horizon, clearly silhouetted against the morning sun shone the silvery towers of Castle Xeron nestling on the hill many leagues away. All was still . . . almost peaceful.

"Listen, old man. I've heard your faerie story — just what is all this about?"

At the sound of the gruff voice, the hooded figure at the window swivelled around using his stick for support and, contemplating the six figures seated around his desk, began the slow and painful journey back to his chair.

"It is no faerie story, my friend" the old man muttered as he eased his back against the oaken carvings of the chair back. "I know the tale to be true for I was that young wizard, Alarian. It was I who, tens of thousands of years ago, sat with Princess Evanna helping her to prepare for her battle with Vounim".

Alarian lifted his hand weakly silencing the doubting questions of the company.

"Please listen. You would not understand the ways I have prolonged my life, so do not ask. Accept simply that I am Alarian and all I speak of is true. The spell of watchfulness I cast so long ago has called me here to protect your lands from great danger"

"With all due respect, Sire, are you not a little late" said another of the figures, a novice wizard by his appearance, "the Valley has been a place of rumour and mystery, concealed by strange mists for nigh on thirty years".

"I'm afraid" sighed Alarian "that you will find out one day soon that not all magic works as effectively as you would wish. I believe my spell of watchfulness was weakened in much the same way as Princess Evanna's spell of banishment. During my time of apprenticeship to Vounim, I too formed a psychic link with my master hoping to amass power before my time. As the fates would have it, Vounim, through the past mystic bonds with the Princess and I, was able to divert much of the strength of our spells, allowing him to attempt a return to the mortal plane unseen.

"Vounim, Lord of the Valley, is smashing a pathway from the chaos of his world of banishment through to our own. In his present situation, halfway between chaos and reality, he is almost visible to me; his followers and his buildings, the Lairs, the Temples and the Black Tower, are already becoming reality again.

"As my wild-eyed barbarian friend pointed out earlier, I am but a frail old man. I can offer nothing but magical aid as I am all but restricted to this chair. Were I stronger, nothing would stop me fulfulling the quest alone but alas, it is to you I look for favour. Will any of you enter the Valley in search of the missing Helm of Evanna in my place".

At the mention of the legendary Helm, the six figures moved closer around the wizard's desk.

"I can help whosoever decides to go" continued Alarian "but I can help only one of you at a time. I can create a path of safety between this castle and Castle Xeron, both of which will prove safe havens during your quest; I can also make the buildings visible to you — although this means you will be seen and thus attacked by the inhuman creatures loyal to Vounim.

"You will need great experience to find the Helm of Evanna; such was Evanna's curse on her people — they spurned her when she needed their help to defeat Vounim. Princess Evanna hid the means to conquer any threat to the Kingdom so that only the bravest Tybollean could ever find it. To gain this experience, you would be wise to first search out my Amulet in one of the Temples of Y'Nagioth and, once found, journey to the Black Tower of Zaexon where you will find the six stones that fit the Amulet. However, care must be taken to find the stones in the correct order — if you don't, you will find they do not fit and will be useless to you .

"Although I have had little contact with my Amulet over past centuries, I am confident I can illuminate areas of residual magic within the Temples and the Black Tower indicating where magical items have been hidden at some time in the past. I will do my best to show you where the Amulet stones have been cached, but I have found that in my latter years I have not the concentration I used to have and you may find only worthless baubles instead — I will do my best".

"Well that's not good enough for me" cried a thief-like character jumping to his feet, "I'm damned if I'll follow you through this Valley — I've heard stories of the creatures who dwell there. Sorcery — hah!" He spat at Alarian's feet and departed.

As the slam of the chamber door died away, Alarian surveyed the five ramaining faces: a barbarian, a novice wizard, a cleric, a thinker and a warrior. Hand-picked and all native Tybolleans, Alarian wondered if one of these could achieve the impossible and bring

back the lost Helm of Evanna.
"I would not blame you for following him" said Alarian "the dangers he spoke of are all too real. Over the past weeks I myself have seen Dragons, Balrogs, Wraiths, even a creature with the very likeness of Y'Nagioth herself, a Thunder Lizard, roaming the Valley through my enchanted glass .

"You will not, however, enter the Valley unprotected. I will teach you a potent sleep spell and, as you gain experience, will be able to bestow two other spells on you: a mind lance to attack creatures with a high psychic power and a spell which attacks using the very Fires of Hell. However, you will use these spells sparingly as they are extremely dangerous in the hands of the untutored and it takes many years of study before a spell can be cast with no loss of stamina.

"You will doubtless have realised that I am no fighting man" continued the wizard, nodding respectfully towards the warrior and the barbarian, "but if I may offer some advice on hand-to-hand combat. There are three effective ways to fight a creature of great physical strength; either strike its head, body or limbs. Obviously an attack to the limbs or body will eventually lead to success, but it may initially cause little damage. A strike to the head may kill the beast in one blow, but will leave you open to return blows while striking. The decision will be yours, I cannot help. However, do not waste your time attacking a purely psychic creature with a sword, they can be defeated by spell only.

"Care must be taken when approaching any building; the swamps and forests are dangerous — make sure you have the experience to cope. Also, beware of water, you will be considerably weakened by the weight of your armour".

Alarian, bringing his stick to the ground raised himself out of his chair.
"I cannot promise you riches, though treasure there be in the Valley, I ask only that you save the Kingdom. Find the Amulet. Fill it with the six stones and you will have the ability to cheat death; to resurrect yourself within these safe castle walls. It will also prove invaluable in your search for the Helm of Evanna in the dark Lord's lair.

"Alas, I cannot help you much in your search for the Helm. For although I can again guide you to the areas of residual magic, the Helm, on its mistress' instruction, will not reveal itself to you unless you have at least the power of a Warlord. It will be up to you to build up this experience, I can only provide an occasional aura of magic to boost your powers, yet you will find that Vounim also has a way of watching over his followers and may surround you in a circle of evil .

"There is little time for discussion; I have arrived thirty years too late . . . and I fear Vounim knows it. The choice must be made here and it must be made now. Will you go and find the Helm of Evanna and bring it back here?"

Each of the five heads nodded as, in turn, Alarian gazed deeply into their eyes. Settling his hands on the carved walking stick at his side, the elderly wizard spoke to the assembled company in a low rumbling voice.
". . . who then will be first?" **RM**

The Valley is best described as a real-time adventure with graphics. It was developed as a direct result of reviewing and testing a large number of commercial offerings over Christmas 1980 and, we hope, overcomes many of the failings of these various alternatives.

The program has always been based on a modular system to simplify both its production and its documentation; this approach also means that the game can be tailored to suit the player's individual tastes. Again, because of the modular nature of the program it can easily be expanded provided you have more than the required 16K.

The published listing was developed and tested on a 32K Commodore PET but will, if all non-essential spaces and REMs are removed, run in 16K. All graphics characters and cursor controls have been converted to CT's standards and screen maps and character tables are provided. We are not suggesting that conversion to other systems is something that can be done in an evening but it is possible — we have versions running on a Sharp MZ80-K and a TRS-80. Because the Sharp uses the same screen format as the PET and is equipped with a very adequate block graphics set we haven't made much comment about conversion to this system but the TRS-80 represented a considerable challenge so a whole section dedicated to explaining the outlines of conversion to this system will be published in our next issue.

Getting It Taped

The best way to implement the program on your system is to key it in one module at a time following the notes. We have broken the listing down into the separate modules, each with a description of its main functions, to make this simpler. As each block is completed SAVE it on tape before adding the next; 16K is a lot of program to lose if you make a mistake!

PET and TRS-80 owners who wish to avoid the strain of typing in all that code can order a cassette version of the program from us (see the advertisement in this issue).

Playing The Game

The objects of the game are explained in the introductory scenario, the actual mechanics of playing are described in the various sections that follow. Probably the best plan is to create a number of different characters, one of each type perhaps, and attempt to play each of them through the Valley and various scenes. The ultimate object of the game is to reach the highest rating level, 28, but along the way you will need to collect the various special treasures to ensure that if you are unfortunate enough to be killed you stand a chance of re-incarnation.

Game tactics are dependent on the type of characters you have chosen and are best developed by the player as the game progresses. A couple of hints may be welcome, however. If you are in a combat with a monster that is stronger than you and are suffering great damage, then Spell 1 is possibly the best option to select. The other important tip is to remember that once you enter a scenario other than the Valley you are committed for a number of turns, so ensure that your stamina level is high.

However, before you can play the game you must enter the program so now is the time to start pressing keys! **HB**

Initialisation

Although it would be regarded as 'proper' to declare all the variables used at the start we have only initialised those necessary to begin the program correctly. Arrays are all DIMensioned to their correct sizes at this point and the vital positioning strings of cursor movements are also created.

The dummy READ routine between 300 and 320 moves the current position in DATA over the first block which will be used later for building castle-type scenes.

Monster data is loaded into three arrays; the monster name, its initial strength and its initial magical power. These starting values are modified according to the 'floor level' of the scene on which it appears. The monster details are presented in Table 1. **HB**

```
 99  REM ** DEFINE MAJOR VARIABLES
100  DIM D(3),G(73),P(8),N(8),S(4),T(2)
110  DIM M$(18),MS(18),N1(18)
120  VG$="":GC$="":F$="":DL$=""
130  TS=0:TN=0:TM=3:CF=0
140  D$="[HOM][21 CD]"
150  D1$=LEFT$(D$,17)
160  SP$="[39 SPC]"
170  R$="[30 CR]"
180  R1$=LEFT$(R$,21)
299  REM ** SKIP SCENE DATA
300  FOR I=1 TO 32
310  READ C$
320  NEXT I
329  REM ** LOAD MONSTER DATA
330  FOR I=0 TO 18
340  READ M$(I):READ MS(I):READ N1(I)
350  NEXT I
```

Character Initialisation

This block of program allows the user to set up his character with a name and one of a number of options of character type; Wizard, Cleric, Barbarian, etc. Table 2 contains information on the various character types.

Alternatively, if the game has been played before, the user may have a character stored on tape so the option exists to load this instead of starting afresh. The selection is made in 1050 after the name has been entered. The maximum length of name is 16 characters (checked in line 1040) and, because the string has to be entered as an INPUT, a simple bomb-proof trap is inserted at line 1030. This works by forcing an asterisk to appear under the cursor so if you simply press RETURN this is entered rather than nothing. This trap should only be needed on the PET, other systems may allow more sophisticated trapping techniques.

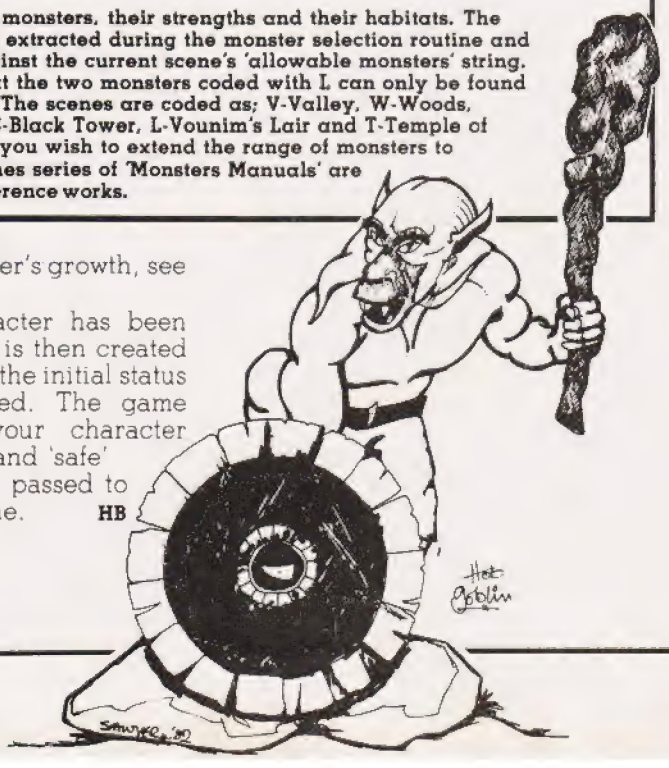
The tape input routine, from 1090 to 1210 is absolutely straightforward and can be changed to suit your system; TRS-80 would use INPUT# −1 followed by the list of variables and MZ80-K would require the file to be ROPENed first. Check your manual to find the appropriate method for your system.

If data entry is from tape, the stamina value is set to maximum and the program then jumps to 1400. If, however, this is the first time through the game, the tape loading section is skipped and the player offered the choice of five character types. According to your selection, the initial values of your character's physical and magical strengths are determined together with your two 'gain' factors. These determine how much you gain from finds and how well various sections of the combat work. The P1 factor also acts as a limit on your character's growth, see Table 2.

Once the character has been selected, the Valley is then created for the first time and the initial status information displayed. The game now starts with your character located in the left-hand 'safe' castle and control is passed to the Movement routine. **HB**

Monster	Physical	Magical	Code	Scenes
Thunder Lizard	50	0	V	V
Wolfen	9	0	A	V,W,S,C
Hob-Goblin	9	0	A	V,W,S,C
Orc	9	0	A	V,W,S,C
Ogre	23	0	A	V,W,S,C
Balrog	50	50	A	V,W,S,C
Fire Imp	7	3	E	V,W,C,L,T
Harpy	10	12	E	V,W,C,L,T
Fire Giant	26	20	E	V,W,C,L,T
Rock Troll	19	0	G	V,C
Centaur	18	14	H	V,W
Wyvern	36	12	F	W,S
Water Imp	15	15	L	W,S
Kraken	50	0	L	W,S
Minotaur	35	25	C	C,L,T
Wraith	0	30	C	C,L,T
Ring Wraith	0	45	C	C,L,T
Barrow Wight	0	25	B	L,T
Dragon	50	20	B	L,T

Table 1. The monsters, their strengths and their habitats. The code letter is extracted during the monster selection routine and matched against the current scene's 'allowable monsters' string. Note also that the two monsters coded with L can only be found in the lakes. The scenes are coded as; V-Valley, W-Woods, S-Swamps, C-Black Tower, L-Vounim's Lair and T-Temple of Y'Nagioth. If you wish to extend the range of monsters to the TSR Games series of 'Monsters Manuals' are valuable reference works.



```
 999  REM ** CHARACTER CHOICE AND LOAD
1000  PRINT "[CLS][CD]LOAD A CHARACTER FROM TAPE (Y/N) ?"
1010  VG$="YN":GOSUB 1500:REM ** UNIGET
1020  INPUT "[CD]CHARACTER'S NAME [2 CR]*[3 CL]";J$
1030  IF J$="*" THEN 1020
1040  IF LEN(J$)>16 THEN PRINT "[CD]TOO LONG":GOTO 1020
1050  IF GC$="N" THEN 1240
1060  PRINT "[CLS]PLACE DATA TAPE IN THE TAPE DECK"
1070  PRINT "[CD]IS IT REWOUND ?"
1080  GOSUB 1600:REM ** ANYKEY
1090  OPEN 1,1,0,J$
1100  INPUT#1,P$
1110  INPUT#1,TS
1120  INPUT#1,EX
1130  INPUT#1,TN
1140  INPUT#1,CS
1150  INPUT#1,PS
1160  INPUT#1,T(0)
1170  INPUT#1,T(1)
1180  INPUT#1,T(2)
1190  INPUT#1,C1
1200  INPUT#1,P1
1210  CLOSE 1
1220  C=150
1230  GOTO 1400
1240  PRINT "[CLS][2 CD]CHARACTER TYPES...CHOOSE
      CAREFULLY"
1250  PRINT
1260  PRINT "WIZARD     (1)"
1270  PRINT "THINKER    (2)"
1280  PRINT "BARBARIAN (3)","KEY 1-5"
1290  PRINT "WARRIOR    (4)"
1300  PRINT "CLERIC     (5)"
1310  GET GC$:IF GC$="" THEN 1310
1320  A=VAL(GC$)
1330  IF A=1 THEN P$="WIZARD":P1=2:C1=0.5:CS=22:PS=28
1340  IF A=2 THEN P$="THINKER":P1=1.5:C1=0.75:CS=24:PS=26
1350  IF A=3 THEN P$="BARBARIAN":P1=0.5:C1=2:CS=28:PS=22
1360  IF A=4 THEN P$="WARRIOR":P1=1:C1=1.25:CS=26:PS=24
1370  IF A=5 THEN P$="CLERIC":P1=1.25:C1=1:CS=25:PS=25
1380  IF A<1 OR A>5 THEN P$="DOLT":P1=1:C1=1:CS=20:PS=20
1390  EX=5:C=150
1400  PRINT "[2 CD]GOOD LUCK"
1410  PRINT "[CD]";J$;" THE ";P$
1420  DF=150:DL$="D":GOSUB 36000:REM ** DELAY
1430  GOSUB 10000:REM ** VALLEY DRAW
1440  DF=5:GOSUB 36000:REM ** DELAY + UPDATE
1450  GOTO 2000:REM ** MOVEMENT
```

Type	P1	C1	CS	PS	C	CS Max	PS Max
Wizard	2.00	0.50	22	28	100	66	777
Thinker	1.50	0.75	24	26	113	72	241
Barbarian	0.50	2.00	28	22	125	77	89
Warrior	1.00	1.25	26	24	113	75	117
Cleric	1.25	1.00	25	25	113	74	157
Dolt	1.00	1.00	20	20	113	75	117

Table 2. The six possible character types with their initial values and the maximums to which their physical and magical strengths can rise.

Fast Subroutines

UNIGET: This is a universal GET routine for the PET and is designed to operate in conjunction with the string VG$. It will only return to the main program if the character keyed is one of those in VG$. On other systems this may be replaced by the INKEY$ function.

ANYKEY: This routine is used in the tape save and load routines to allow the player to ensure the cassette is ready in the tape machine before proceeding, it can be removed or replaced as required.

COMBAT GET: A special timed GET routine for combat. It returns to the main program as soon as any key is pressed, assuming that this occurs within the time limit. The key pressed is held in GC$. If the time limit is exceeded the variable TV is set to 1. The routine also wipes away the text message "*** STRIKE QUICKLY ***" **HB**

```
1499  REM ** UNIGET ROUTINE
1500  GET GC$:IF GC$="" THEN 1500
1510  FOR I=1 TO LEN(VG$)
1520  IF MID$(VG$,I,1)=GC$ THEN RETURN
1530  NEXT I
1540  GOTO 1500
1599  REM ** ANYKEY ROUTINE
1600  PRINT "[CD]** PRESS ANY KEY TO CONTINUE **"
1610  GET GC$:IF GC$="" THEN 1610
1620  RETURN
1699  REM ** COMBAT GET ROUTINE
1700  FOR I=1 TO 10:GET GC$:NEXT I:REM ** EMPTIES BUFFER
1710  TV=0
1720  FOR I=1 TO 60
1730  GET GC$:IF GC$="" THEN 1750
1740  GOTO 1770
1750  NEXT I
1760  TV=1:REM ** NO KEY PRESSED
1770  PRINT D$;SP$:REM ** WIPE AWAY MESSAGE
1780  RETURN
```

Movement

In many ways this represents the core of the whole program; it is certainly the most executed loop and controls access to all other major routines.

For such an important routine it occupies surprisingly little space, lines 2000 to 2250 in fact. Line 2000 is only used as an initial starting point when you first enter the Valley, either at the start of the game or when you return to the Valley from a scenario; all other calls are made to 2010. The POKE code 81 is the symbol used to display your current position in the Valley, Table 3 gives alternatives for other systems.

The first operation is to give the character stamina a boost of 10, a dynamic refresh? Your current position is now examined to see if you are standing on a path or in the Valley and an appropriate message is printed requesting you to make a move. The player may move one square at a time in any direction, see Fig. 1. The choice of direction is made by keying one of the keys of the numeric keypad, the value of the key pressed then being inspected to find which direction it represents. In many programs of this type the checking is done by way of a look-up table which, although universal in operation and not restricted to numeric keypads is expensive in terms of memory.

Fortunately, one of the programming team had a mathematical background and produced the code between 2050 and 2090. Because each direction of movement corresponds directly to a screen displacement value, it must be possible to establish a simple mathematical relationship between the numeric key pressed and the direction in which you wish to move. In fact, the relationship is so simple no one appears to have thought of it before; another first for CT!

The routine starts at 2050 by clearing out the keyboard buffer, an essential operation to prevent old keystrokes causing problems. A character is now read in by the GET command in 2060 and checked to see if it is an 'E'. If it is an 'E', control is passed to the rating routine which gives your current 'Ego'. As we are only looking for numeric inputs in this routine we can test for validity by finding the VAL of the character; if this is 0 it must have been non-numeric so the program loops back for another character.

Once a valid key has been pressed, its value is held in the variable A and testing starts at line 2080. The first piece of code repetitively subtracts 3 from the value of A to determine the horizontal displacement. If keys 1,4 or 7 have been pressed we must wish to move left; 3,6 and 9 indicate a move to the right and 2,5 and 8 maintain the current column position. As we are now left with a number between 1 and 3, we can determine the horizontal displacement by subtracting 2 from this remainder and this is done in 2090.

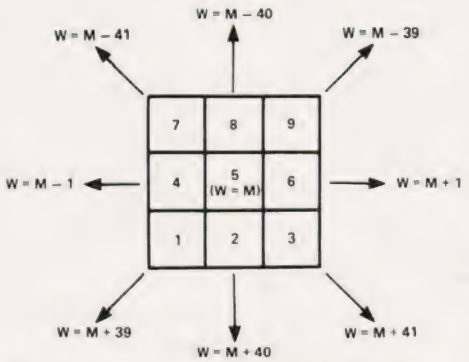


Fig. 1. The directions corresponding to the keys on a numeric pad together with their 40-column displacements.

Scene	Object	PET	MZ80-K	TRS-80
Valley	Border	214	166	191
	Safe Castle	219	74	35
	Path 'up'	78	118	154
	Path 'down'	77	119	169
	Woods	216	80	87
	Swamps	173	42	83
	Tower	87	65	84
	Character	81	202	79
Woods	Border	96	*	128
	Trees	88	70	90
	Lake	224	163	191
	Vounim's	230	239	86
	Character	81	202	79
Swamps	Border	96	*	128
	Tufts	45	227	45
	Lake	224	163	191
	Y'Nagioth	230	239	89
	Character	81	202	79
Tower Vounim & Y'Nagioth	Border	160	67	191
	Walls	160	67	191
	Stairs	102	109	153
	Doorway	104	212	176
	Treasures	42	107	42
	Character	81	202	79

Table 3. These are the recommended POKE codes for the three systems the game has been implemented on. The borders around the Woods and Swamps for the MZ80-K (marked * in the Table) have to be PRINTed into place using the following characters: 50,51,60,61,112,113,114 and 115. This provides a neat border at the expense of extra entries in the look-up table.

Fig. 2. The mathematical sequence required to convert key value to row displacement.

7	8	9
4	5	6
1	2	3

(a) VAL (GC$)

6	7	8
3	4	5
0	1	2

(b) VAL (GC$) – 1

2	2.3	2.6
1	1.3	1.6
0	0.3	0.6

(c) (VAL (GC$) – 1) / 3

2	2	2
1	1	1
0	0	0

(d) INT((VAL (GC$) –1) / 3

1	1	1
0	0	0
–1	–1	–1

(e) INT ((VAL (GC$) – 1) / 3 –1

–40	–40	–40
0	0	0
+40	+40	+40

(f) – 40* (INT ((VAL (GC$) – 1) / 3) – 1)

All we have to do now is to determine the correct vertical displacement, this also being computed in line 2090. Assuming a 40 column screen we must now establish the row we wish to move to; this is best explained by referring to Fig. 2. If we subtract 1 from the key value (Fig. 2b) and then divide by 3 (Fig. 2c) the INTeger part of the remaining number is related to both the key value and its corresponding row (Fig. 2d). Subtract 1 and multiply by – 40 and the resulting number is the vertical displacement.

Having computed the address of the position you wish to move to (held in variable W), we can now start to check what is in that position. These checks are preceded in line 2100 by incrementing the turns count and clearing away the movement message. The next block of lines inspects the contents of address W and is best shown as a small table:

Line	Character	Action
2110	Nothing	Jump to Movement
2120	Safe Castle	Jump to Quit routine
2130	Solid object	Try again!
2140	Scene code	Jump to Scene Control
2150	Scene exit	Jump to Scene Control
2160	Stairs	Jump to Stairs routine
2170	Lakes	Reverse the character code
2180	Special find	Jump to Special Finds

After all these checks have been performed it only remains to move your character into its selected position; line 2190 does this and, because you stepped on a blank square, the program now generates a random number to see if there is either a hidden 'find' or a waiting monster. It does this in lines 2200 to 2220 and, depending on the value of the random number, control may be passed to either the Monster Selection routine or to the Finds routine.

If nothing is found a suitable message is printed and the program loops back to the beginning of movement at 2010. The DF value of 80 in line 2230 enables you to read the message; if you have stepped on the path, checked in line 2200, the delay is only set to 5 because there is no message to read. **HB & PNG**

```
1999  REM ** MOVEMENT ROUTINE
2000  M=W:PK=PEEK(W):POKE M,81
2010  C=C+10
2020  IF PK=77 OR PK=78 THEN 2040
2030  PRINT D$;"YOUR MOVE...WHICH DIRECTION ?":GOTO 2050
2040  PRINT D$;"SAFE ON THE PATH...WHICH WAY ?"
2050  FOR I=1 TO 10:GET GC$:NEXT I:REM ** CLEAR K&D BUFFER
2060  GET GC$:IF GC$="E" THEN 45000:REM ** EGO
2070  REM ** SPECIAL ROUTINE FOR NUMERIC KEYPADS
2080  A=VAL(GC$):IF A=0 THEN 2060
2090  IF A>3 THEN A=A-3:GOTO 2080
2095  W=44A-2-40*(INT((VAL(GC$)-1)/3)-1)
2100  TN=TN+1:PRINT D$;SP$
2105  REM ** AM I STEPPING ON SOMETHING ?
2110  Q=81:Q1=PEEK(W):IF Q1=32 OR Q1=46 THEN 2190
2120  IF Q1=219 THEN 48000:REM ** QUIT
2130  IF Q1=214 OR Q1=160 OR Q1=32 THEN TN=TN-1:GOTO
      2030:REM ** HIT WALL OR TREE
2140  IF Q1=215 OR Q1=87 OR Q1=173 OR Q1=230 THEN 9000:
      REM ** SCENE ENTRY
2150  IF Q1=104 OR Q1=95 THEN 9090:REM ** SCENE EXIT
2160  IF Q1=102 THEN 15000:REM ** STAIRS
2170  IF Q1=224 OR (GC$="S" AND PK=224) THEN Q=209:
      C=C-30:IF C<=0 THEN 55000:REM ** WATER
2180  IF Q1=42 THEN 2800:REM ** SPECIAL FIND
2190  POKE M,PK:PK=PEEK(W):M=W:POKE M,Q
2200  IF PK=77 OR PK=78 THEN DF=5:GOTO 2250
2209  REM ** NOTHING, MONSTER OR FIND PERHAPS ?
2210  RF=RND(TI)
2220  IF RF<0.33 THEN 3000:REM ** MONSTER SELECT
2230  IF RF>0.75 THEN 2300:REM ** FIND SELECT
2240  PRINT D$;"NOTHING OF VALUE...SEARCH ON":DF=80
2250  GOSUB 36000:REM ** DELAY + UPDATE
2260  GOTO 2010
```

Finds

The 'ordinary finds' module starts lines 2300-2310 by randomly selecting one of four finds — three good, one not so good. A random integer between 1 and 6 is generated and two line numbers appear twice in the ON . . . GOSUB list thus giving probabilities of roughly 16%, 32%, 32% and 16% to the finds.

The first find, starting at 2340, is the bad one. Although line 2350 boosts combat strength by an amount dependent on FL, magical ability drops (FL again being a factor) and stamina is reduced by 20. Line 2360 jumps to the Death routine if C falls below zero.

At line 2380 'a hoard of gold' is found. Treasure is incremented by a value between 100 and 700, depending on FL and a random factor. The third and fourth finds are not monetary but physical and magical; although different messages are printed, lines 2140 and 2440.

Each of the four subroutines returns to line 2330 for a delay and update before control is returned to the Movement routine, line 2010.

PNG

```
2299  REM ** FINDS ROUTINE
2300  RF=INT(RND(TI)*6+1)
2310  ON RF GOSUB 2340,2380,2380,2410,2410,2440
2320  DF=80:GOSUB 36000:REM ** DELAY + UPDATE
2330  GOTO 2010
2340  PRINT D$;"A CIRCLE OF EVIL...DEPART IN HASTE !"
2350  CS=CS+INT((FL+1)/2):PS=PS-INT((FL+1)/2):C=C-20
2360  IF C<=0 THEN 55000:REM ** DEATH
2370  RETURN
2380  PRINT D$;"A HOARD OF GOLD"
2390  TS=TS+INT(FL*RND(TI)*100+100)
2400  RETURN
2410  PRINT D$;"YOU FEEL THE AURA OF THE DEEP MAGIC..."
2420  PRINT "[8 SPC]...ALL AROUND YOU..."
2430  GOTO 2450
2440  PRINT D$;"...A PLACE OF ANCIENT POWER..."
2450  PS=PS+2+INT(FL*P1):CS=CS+1+INT(FL*C1):C=C+25
2460  RETURN
```

Special Finds

If the Movement routine establishes that you have stepped onto an asterisk, a jump is made to the Special Finds module at line 2800. Here you are placed on the marker which is then erased (PK = 32); once you've picked up a special find, it's gone for good! Next, a random number is generated to decide what you've found; the 'Movement' message is wiped and a series of tests begins.

The first test (line 2820) succeeds if you're in Vounim's Lair, S = 6, have a full Amulet, T(1) = 6, a rating greater than 25, and have not already found the Helm of Evanna, T(2) = 0. You also have to be very lucky, RN > 0.95!

Line 2830 tests for the empty Amulet; this can only be found in the Temple of Y'Nagioth, S = 5, with RN > 0.85. You may only have one Amulet at a time, T(0) = 0. Note that although you need a full Amulet to obtain the Helm, losing the Amulet later (through reincarnation) means you are free to find another one; no problems arise if you already have the Helm.

The next line, 2840, checks for Amulet stones which only occur in the Black Tower, S = 4. Not only must you first have the Amulet, T(0) = 1, and space left in it, T(1) < 6, but you must be on a sufficiently high floor. The first stones can be found low down the Tower but as you find each stone you must venture higher to find the remaining ones, FL > T(1). Assuming you have found an Amulet stone, lines 2910-2920 decide whether it fits or not. Since RN must already be greater than 0.7 to get to these lines, the condition that RN > 0.85 here gives a 50-50 chance of the stone being the right one.

If the tests in lines 2820-2840 all fail then you have found either a precious stone or a worthless bauble. The random factor of 0.43 in line 2850 was chosen to get a long-term average of roughly 50% between precious stones and worthless baubles since RN may have been 'filtered' by the previous tests. For example, if all three tests failed on factors other than the value of RN, it could be anything between 0 and 1 on line 2850 and the probability is 43% that you have a worthless bauble. On the other hand, if line 2840 failed only because RN < 0.7 then the probability shifts to 0.43/0.7 = 61.4%.

As well as obtaining the objects themselves your treasure, TS, is updated in line 2930 by an amount which depends on the number of items you've already found. Baubles and wrong Amulet stones don't count and bypass this line.

PNG

```
2799  REM ** SPECIAL FINDS ROUTINE
2800  POKE M,32:M=W:PK=32:POKE M,81
2810  RN=RND(TI):PRINT D$;SP$
2820  IF S=6 AND RN>0.95 AND T(1)=6 AND T(2)=0 AND RT>25
      THEN T(2)=1:GOTO 2870
2830  IF S=5 AND RN>0.85 AND T(0)=0 THEN T(0)=1:GOTO 2880
2840  IF S=4 AND RN>0.7 AND T(0)=1 AND T(1)<6 AND FL>T(1)
      THEN 2890
2850  IF RN>0.43 THEN PRINT D$;"A WORTHLESS BAUBLE":
      GOTO 2940
2860  PRINT D$;"A PRECIOUS STONE !":GOTO 2930
2870  PRINT D$;"YOU FIND THE HELM OF EVANNA !":GOTO 2930
2880  PRINT D$;"THE AMULET OF ALARIAN...EMPTY...":
      GOTO 2930
2890  PRINT D$;"AN AMULET STONE...":PRINT
2900  DF=60:DL$="D":GOSUB 36000:REM ** DELAY
2910  IF RN>0.85 THEN PRINT "[CD]...BUT THE WRONG ONE !":
      GOTO 2940
2920  PRINT "[CD]...THE STONE FITS !":T(1)=T(1)+1
2930  TS=TS+100*(T(0)+T(1)+T(2)+FL)
2940  DF=80:GOSUB 36000:REM ** DELAY + UPDATE
2950  GOTO 2010
```

Monster Selection

If you have the misfortune to draw a monster at the end of the Movement routine, control is passed to the segment of code which starts at 3000. A random number is generated between 1 and 16 and tested to see if it is greater than 9. This test is made to ensure that the stronger monsters cannot occur too frequently; the checks and limits for this are established in line 3020.

If the character is currently standing or swimming in a lake the choice of monsters is limited to the Water Imp and the Kraken, both prefixed L in the DATA.

The most unpleasant general monster is the Balrog and if he is drawn from the array, a further check is made in line 3040 to ensure that he appears less frequently.

Some monsters live only in the rarified heights of the Black Tower or one of the two special castle-type scenes and if these are drawn from the array, a further check is made in line 3050 to ensure that these conditions are met.

Once an acceptable monster has been selected from the array, the left-hand character of its name is stripped off to see if it can exist in the current scenario; this character is then checked against F$ in lines 3060 to 3090. If all is correct, the chosen beast is displayed on the screen and combat commences. The base strengths of each monster are held in arrays MS() and N1() and these values are further modified by the code between lines 3120 and 3170 to produce the actual strengths of the chosen monster. **HB**

```
2999  REM ** MONSTER SELECTION ROUTINE
3000  PRINT D$;"** BEWARE...THOU HAST ENCOUNTERED **"
3010  MS=0:N=0:CF=1
3020  RF=INT(RND(TI)*17):IF RF>9 AND RND(TI)>0.85
      THEN 3020
3030  IF Q1=224 OR PK=224 THEN RF=INT(RND(TI)*2+17)
3040  IF RF=16 AND RND(TI)<0.7 THEN 3020
3050  IF FL<5 AND RF=15 THEN 3020
3060  X$=LEFT$(MS(RF),1)
3070  FOR I=1 TO LEN(F$)
3080  IF MID$(F$,I,1)=X$ THEN 3110
3090  NEXT I
3100  GOTO 3020
3110  M$=RIGHT$(M$(RF),LEN(M$(RF))-1)
3120  IF MS(RF)=0 THEN 3150
3130  MS=INT((CS*0.3)+MS(RF)*FL^0.2/(RND(TI)+1))
3140  IF N1(RF)=0 THEN 3160
3150  N=INT(N1(RF)*FL^0.2/(RND(TI)+1))
3160  U=INT((RF+1)*(FL^1.5))
3170  IF RF>23 THEN U=INT((RF-22)*FL^1.5)
3180  PRINT "[CD]";LEFT$(R$,12-(LEN(M$))/2);"AN EVIL ";M$
3190  DF=40:GOSUB 36000:REM ** DELAY + UPDATE
```

Character's Combat

The action of fighting a monster can be broken down into three main sections; you hitting it, it hitting you and you casting a spell. The Spells are controlled by their own section of code that will be described later and can be simply treated as a jump out of the physical combat routines.

The Character's Combat section is located from 3570 to 3910 but before this can be executed we must determine whether you have surprised the beast or not. This is tested for in line 3500 where a random number is generated giving a 60/40 chance of you surprising the monster. If you do have surprise you are then offered the option of retreating from combat. The "R" key must be pressed within the time limit of the Combat Get routine or control passes directly to the Monster's Combat.

If you do choose to retreat a suitable message is displayed and the program goes back to the Movement routine. Choosing to attack, the message "*** Strike Quickly ***" is displayed and you have the choice of attacking its Head, Body or Limbs with the further option of trying to cast a Spell. If no key was pressed or the wrong one was chosen, control passes to the Monster's Combat via a suitable message. The control for this section of the combat is handled by lines 3570 to 3600.

Assuming that you have pressed a valid key the program checks in line 3630 to see if you wished to cast a spell and if so passes control to the Spell Control section. Before determining how much damage, if any, you have done to the beast, the program computes your current experience factor in line 3620 and deducts one stamina point. If you have exhausted yourself attempting to fight, the program detects this in 3660 and passes control to the Death routine.

Because each of the three target areas of the monster have different levels of vulnerability the code between 3670 and 3710 determines whether you hit the beast or not and, if you did, sets the damage factor variable, Z, to the appropriate level. As it is possible to strike a heavy blow which will leave the monster helpless we must first inspect the corresponding flag, HF, which tells us if the beast is certain to die on this attempt. If this flag has not been set in line 3730, we calculate the damage done to the monster and display it — it is possible to hit the monster yet do no damage! There are now several options available to us and these are sorted out by the rest of the routine from 3800 to 3910. The first alternative is that we have killed it, in which case we collect experience, reset the combat flags and go back to the movement routine (lines 3860 to 3890). Our second option is that we have done so much damage to the beast that it is unable to have another go at us. In this case we set the flag, HF, and go back to the "*** Strike Quickly ***" message. The remaining alternative is that we either did no damage or insufficient to cripple the monster and in both cases, control now passes to the Monster's Combat routine. **HB**


```
3499  REM ** CHARACTER'S COMBAT ROUTINE
3500  IF RND(TI)<0.6 THEN 4000:REM ** MONSTER'S COMBAT
3510  PRINT D$;"YOU HAVE SUPRISE...ATTACK OR RETREAT"
3520  GOSUB 1700:REM ** COMBAT GET
3530  IF GC$="R" THEN 3900
3540  IF TV=1 THEN 3600
3550  IF GC$<>"A" THEN 4000
3560  DF=30:DL$="D":GOSUB 36000:REM ** DELAY
3570  PRINT D$;"*** STRIKE QUICKLY ***"
3580  GOSUB 1700:REM ** COMBAT GET
3590  IF TV=0 THEN 3620
3600  PRINT D$;"** TOO SLOW...TOO SLOW **"
3610  HF=0:GOTO 3830
3620  E=39*LOG(EX)/3.14
3630  IF GC$="S" THEN 4500:REM ** SPELL CONTROL
3640  IF MS=0 THEN PRINT D$;"YOUR SWORD AVAILS YOU NOUGHT
      HERE":GOTO 3830
3650  C=C-1
3660  IF C<=0 THEN PRINT D$;"YOU FATALLY EXHAUST YOURSELF"
      GOTO 55000:REM ** DEATH
3670  RF=RND(TI)*10
3680  IF GC$="H" AND (RF<5 OR CS>MS*4) THEN Z=2:GOTO 3730
3690  IF GC$="B" AND (RF<7 OR CS>MS*4) THEN Z=1:GOTO 3730
3700  IF GC$="L" AND (RF<9 OR CS>MS*4) THEN Z=0.3:
      GOTO 3730
3710  PRINT D$;"YOU MISSED IT !"
```

```
3720  HF=0:GOTO 3830
3730  IF HF=1 THEN D=MS+INT(RND(TI)*9):HF=0:GOTO 3760
3740  D=INT((((CS*50*RND(TI))-(10*MS)+E)/100)*Z):IF D<0
      THEN D=0
3750  IF CS>(MS-D)*4 THEN HF=1
3760  MS=MS-D
3770  PRINT D$;"A HIT..."
3780  DF=60:DL$="D":GOSUB 36000:REM ** DELAY
3790  IF D=0 THEN PRINT D$;"[8 CR]BUT...NO DAMAGE":HF=0:
      GOTO 3830
3800  PRINT D$;"[8 CR]";D;" DAMAGE...":IF MS<=0 THEN
      3860:REM ** IT'S DEAD
3810  IF HF=1 THEN DF=30:DL$="D":GOSUB 36000:REM ** DELAY
3820  IF HF=1 THEN PRINT "[CD]THE ";M$;" STAGGERS
      DEFEATED"
3830  DF=110:GOSUB 36000:REM ** DELAY + UPDATE
3840  IF HF=1 THEN 3570
3850  GOTO 4000:REM ** MONSTER'S COMBAT
3860  PRINT D$;"[2 CD]...KILLING THE MONSTER..."
3870  EX=EX+U:HF=0:CF=0
3880  DF=80:GOSUB 36000:REM ** DELAY + UPDATE
3890  GOTO 2010:REM ** MOVEMENT
3900  PRINT D$;"KNAVISH COWARD !":CF=0
3910  GOTO 3880
```

Monster's Combat

Unlike the character, the monster has only two possible methods of attack. Its normal approach is to hit you but as magical monsters, ones with no physical strength, are unable to wield swords and the like, there is the option to attack you with a lightning bolt. To make life even more unpleasant this option is extended to a physical monster whose strength has fallen below its psi power!

The options for the monster are checked at the beginning of its routine, lines 4000 to 4040, before a random number is generated line 4050 determining the outcome. The random number can be between 1 and 10 and there are eight possible messages, two messages appearing twice. Depending on the value of the random number the appropriate message is selected by line 4060 and control is passed to the appropriate section of the routine.

If the monster has missed you or used up all its stamina in the attempt, the section between 4240 and 4290 takes the program back to the Character's Combat or the Movement routine respectively.

Just as your character can hit a selected area of the beast, the reverse is now true but the area is selected randomly by line 4060. Again, as in the Character's Combat, a damage factor Z is set to an appropriate value and the potential damage done to you 'G' is calculated by line 4160. This amount is deducted from your character's stamina by line 4180 and your health is then examined by line 4220; if you are now an ex-character, control is passed to the Death routine.

As mentioned earlier in this section the monster can throw a lightning bolt at you and if this option is selected by line 4030, control is passed to the section of program from 4300 to 4410. This computes the possibility of the lightning bolt hitting or missing and, if it hits, how much damage will result.

The outcome of the Monster's Combat routine is again a three-way option; it has killed you so the game jumps to Death; it has wounded but not killed (or missed completely) so control passes back to Character's Combat; or it has killed itself in which case control passes back to the Movement section. **HB**

```
3999  REM ** MONSTER'S COMBAT ROUTINE
4000  PRINT D$;"THE CREATURE ATTACKS..."
4010  DF=50:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
4020  IF MS=0 THEN 4300:REM ** PSIONIC ATTACK
4030  IF MS<N AND N>6 AND RND(TI)<0.5 THEN 4300
4040  MS=MS-1:IF MS<=0 THEN 4240
4050  RF=INT(RND(TI)*10+1)
4060  ON RF GOTO 4070,4080,4090,4100,4110,4110,4120,4120,
      4130,4140
4070  PRINT D$;"IT SWINGS AT YOU...AND MISSES":GOTO 4280
4080  PRINT D$;"YOUR BLADE DEFLECTS THE BLOW":GOTO 4280
4090  PRINT D$;"...BUT HESITATES, UNSURE...":GOTO 4280
4100  Z=3:PRINT D$;"IT STRIKES YOUR HEAD !":GOTO 4150
4110  Z=1.5:PRINT D$;"YOUR CHEST IS STRUCK !":GOTO 4150
4120  Z=1:PRINT D$;"A STRIKE TO YOUR SWORDARM !":
      GOTO 4150
4130  Z=1.3:PRINT D$;"A BLOW TO YOUR BODY !":GOTO 4150
4140  Z=0.5:PRINT D$;"IT CATCHES YOUR LEGS !"
4150  DF=60:DL$="D":GOSUB 36000:REM ** DELAY
4160  G=INT((((MS*75*RND(TI))-(10*CS)-E)/100)*Z)
4170  IF G<0 THEN G=0:PRINT D$;"...SAVED BY YOUR
      ARMOUR ![2 SPC]":GOTO 4280
4180  C=C-G
4190  IF G>9 THEN CS=INT(CS-G/6)
4200  IF G=0 THEN PRINT D$;"SHAKEN.....BUT NO DAMAGE
      DONE":GOTO 4280
4210  PRINT D$;"YOU TAKE...[6 SPC][6 CL]";G;" DAMAGE...
      [6 SPC]"
4220  IF CS<=0 OR C<=0 THEN 55000:REM ** DEATH
4230  GOTO 4280
4240  PRINT D$;"...USING ITS LAST ENERGY IN THE ATTEMPT"
4250  EX=INT(EX+U/2):CF=0
4260  DF=100:GOSUB 36000:REM ** DELAY + UPDATE
4270  GOTO 2010:REM ** MOVEMENT
4280  DF=100:GOSUB 36000:REM ** DELAY + UPDATE
4290  GOTO 3570:REM ** CHARACTER'S COMBAT
4299  REM ** MONSTER'S PSIONIC ATTACK
4300  PRINT D$;"...HURLING A LIGHTNING BOLT AT YOU !"
4310  G=INT(((180*N*RND(TI))-(PS+E))/100):N=N-5:IF G>9
      THEN N=N-INT(G/5)
4320  DF=80:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
4330  IF N<=0 THEN N=0:GOTO 4240
4340  IF RND(TI)<0.25 THEN 4410
4350  IF G<=0 THEN G=0:GOTO 4400
4360  PRINT D$;"IT STRIKES HOME !"
4370  DF=110:GOSUB 36000:REM ** DELAY + UPDATE
4380  C=C-G:IF G>9 THEN PS=INT(PS-G/4)
4390  GOTO 4210
4400  PRINT D$;"YOUR PSI SHIELD PROTECTS YOU":GOTO 4280
4410  PRINT D$;"...MISSED YOU !":GOTO 4280
```

Spell Control

If the option of using a spell is chosen during the Combat routine, control jumps to the routine located from 4500. An initial message is displayed asking which spell you wish to cast and the player's reply is collected by the Combat Get routine.

If you don't press a key within the allotted time the program jumps back to the "Too Slow" message and you have missed your chance; this test is performed in line 4510.

As there are only three spells available in the 16K version (we've left plenty of room for expansion) a check is made at line 4520 to ensure that the key you pressed is valid and if not, a suitable message is printed and control passes back to the Combat routine through line 4640.

Given that you have pressed a valid key, line 4540 now checks to see if you are strong enough to use the chosen spell; if not, control jumps to line 4590 with a suitable message and, once again, the program goes back to the Combat routine via line 4640.

If you meet the requirements to use the spell the appropriate subroutine is selected by line 4550 and control passes to the chosen spell subroutine.

On RETURNing from the spell subroutine a flag variable, SC, will have been set to a value betwen 1 and 7 and this value represents the outcome of casting the spell. Line 4560 causes the program to jump to the correct message and result. **PF**


```
4499  REM ** SPELL CONTROL ROUTINE
4500  PRINT D$;"WHICH SPELL SEEK YE ? ":GOSUB 1700:REM **
      COMBAT GET
4510  IF TV=1 THEN 3600:REM ** TOO SLOW
4520  IF VAL(GC$)>0 AND VAL(GC$)=<3 THEN 4540
4530  PRINT D$;"NO SUCH SPELL...[5 SPC]":GOTO 4640
4540  IF 4*PS*RND(TI)<=N THEN 4590
4550  ON VAL(GC$) GOSUB 5000,5200,5400
4559  REM ** SC CONTAINS OUTCOME FLAG
4560  ON SC GOTO 4620,4640,4660,4570,4600,4580,4590
4570  PRINT D$;"IT IS BEYOND YOU[5 SPC]":GOTO 4640
4580  PRINT "BUT THE SPELL FAILS...!":GOTO 4640
4590  PRINT D$;"NO USE, THE BEAST'S PSI SHIELDS IT":
      GOTO 4640
4600  PRINT D$;"THE SPELL SAPS ALL YOU STRENGTH"
4610  GOTO 55000:REM ** DEATH
4620  DF=100:GOSUB 36000:REM ** DELAY + UPDATE
4630  GOTO 2010:REM ** MOVEMENT
4640  DF=60:GOSUB 36000:REM ** DELAY + UPDATE
4650  GOTO 4000:REM ** MONSTER'S COMBAT
4660  DF=60:GOSUB 36000:REM ** DELAY + UPDATE
4670  GOTO 3570:REM ** CHARACTER'S COMBAT
```

The Spells

SLEEPIT: The first checks made in this subroutine are in line 5000 where stamina is deducted and, if your total has dropped below 0, the program is RETURNed via line 4560 to the Death routine. If your stamina is still healthy the message for the spell is printed by lines 5010 to 5050 moving on to line 5060 to see if the spell actually worked.

The possibility of the spell working is 50% and if successful the program prints the welcome message and updates your experience before going back to the Movement routine via line 4560. If it fails the program still RETURNs via 4560 but the value of the SC flag variable passes control to the Monster's Combat.

PSI-LANCE: An initial check is made in line 5200 to see if the character has met the requirements for the spell to function, if not the program RETURNs to 4560 and then to the Monster's Combat after displaying a suitable message.

Once again the cost to the character in stamina is deducted, this time in line 5210, and the check made to see if he has exhausted himself is done. If you are still alive and fighting, the check is made in line 5220 to see if you are really attacking a monster with some psi power, if not then you are wasting your time so control passes back via 4560 to the Monster's Combat.

If all is well at this stage the text for the spell is printed by lines 5230 and 5240 and the test to see if the spell was successful is then made at line 5250. If the spell failed the program RETURNs to line 4560 and the Monster's Combat after printing a suitable message.

The amount of damage your spell did to the monster is calculated in 5260 and if no damage was inflicted the program goes back to 4560 and the Monster's Combat. If you did damage the creature the amount inflicted is displayed and deducted from monster's strength and psi power and these values are then checked to see if the monster has expired by line 5310. If the monster is still alive the program returns to Monster's Combat via 4560 otherwise line 5320 tells you that you have killed the beast and your experience is subsequently updated by line 5330 and the program RETURNs to 4560 and then back to the Movement routine.

CRISPIT: Once again an initial test is made to see if your character meets the requirements to use the spell, if not, it's back to line 4560 and then to the Monster's Combat. If you can use the spell line 5410 tests to see if the stamina you use to cast the spell has killed you off; if it has it passes control to Death via 4560.

The spell message is printed by lines 5420 to 5470 before line 4580 computes the outcome of the spell. Once again, if the spell failed it RETURNs to 4560 and then to the Monster's Combat.

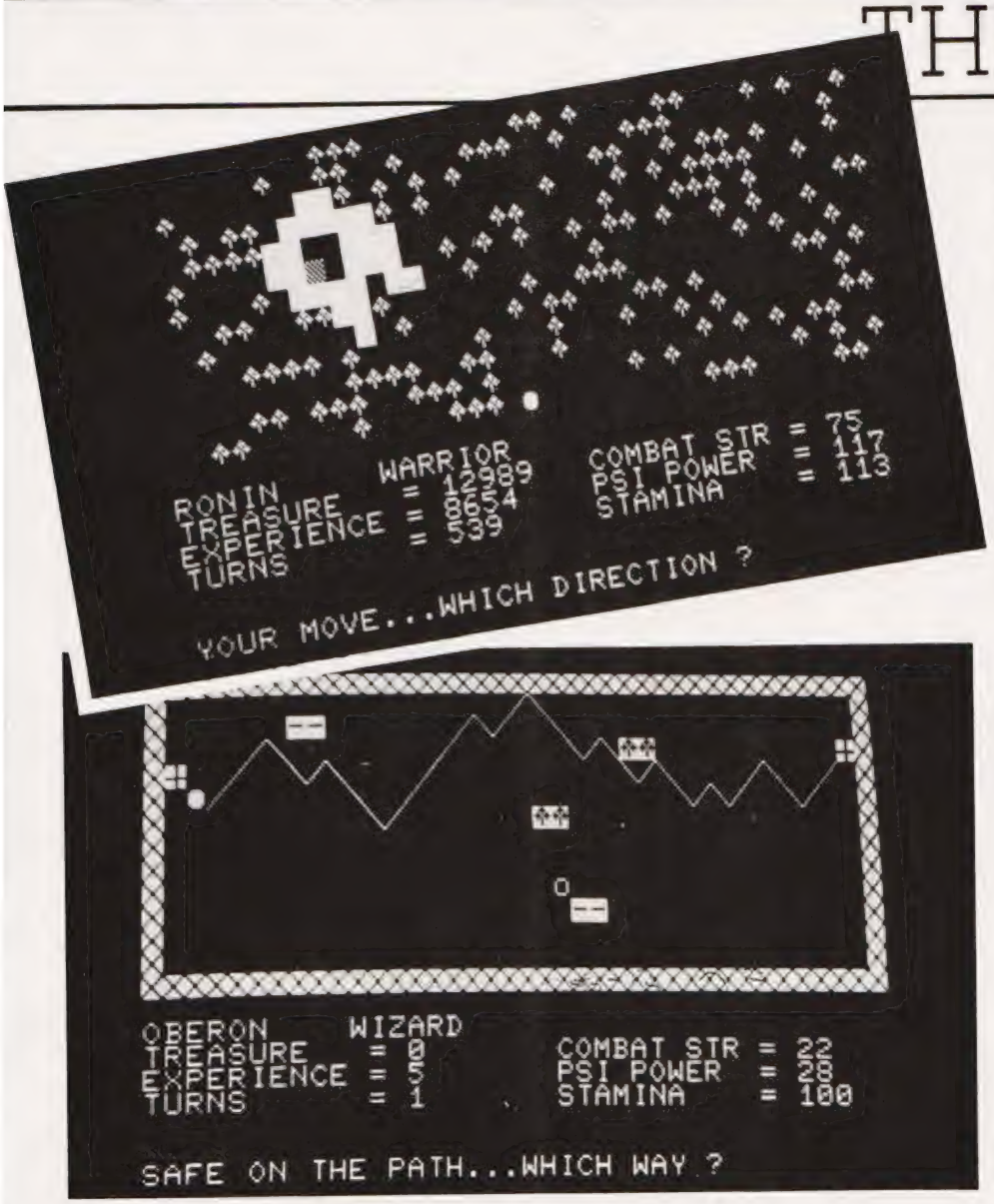
If the spell worked, line 5490 calculates the damage done; if none, then it's back to 4560 and the Monster's Combat again! Given that the spell has worked, the damage is deducted from the monster's physical strength and if it hasn't got any it is deducted from its psi power; all this is handled by lines 5510 to 5530. In fact, if you do more than a certain amount of damage, line 5520 takes some extra points off the psi power as well.

The rest of the routine is concerned with printing out the amount of damage done and checking to see if the monster is now dead. Depending on the result of these tests the program can jump to either the Movement routine or the Monster's Combat via the ever-faithful 4560. **PF**

```
4999  REM ** SPELL 1 (SLEEPIT)
5000  C=C-5:IF C<=0 THEN SC=5:RETURN
5010  PRINT D$;"SLEEP YOU FOUL FIEND THAT I MAY ESCAPE"
5020  PRINT "AND PRESERVE MY MISERABLE SKIN"
5030  DF=180:GOSUB 36000:REM ** DELAY + UPDATE
5040  PRINT D$;"THE CREATURE STAGGERS..."
5050  DF=40:DL$="D":GOSUB 36000:REM ** DELAY
5060  IF RND(TI)<0.5 THEN 5090
5070  PRINT "AND COLLAPSES...STUNNED"
5080  EX=INT(EX+U/2):CF=0:SC=1:RETURN
5090  PRINT "BUT RECOVERS WITH A SNARL !"
5100  SC=2:RETURN


5199  REM ** SPELL 2 (PSI-LANCE)
5200  IF MS>C OR PS<49 OR EX<1000 THEN SC=4:RETURN
5210  C=C-10:IF C<=0 THEN SC=5:RETURN
5220  IF N=0 THEN PRINT D$;"THIS BEAST HAS NO PSI TO
      ATTACK":SC=2:RETURN
5230  PRINT D$;"WITH MY MIND I BATTLE THEE FOR MY LIFE"
5240  DF=120:GOSUB 36000:REM ** DELAY + UPDATE
5250  RF=RND(TI):IF RF<0.4 AND N>10 THEN SC=6:RETURN
5260  D=INT(((((CS*50*RF)-5*(MS+N)+E)/50)/4)
5270  IF D<=0 THEN D=0:SC=7:RETURN
5280  PRINT D$;"THE PSI-LANCE CAUSES ";D*2;" DAMAGE"
5290  N=N-3*D:IF N<=0 THEN N=0
5300  MS=MS-D:IF MS<=0 THEN MS=0
5310  IF (MS+N)>0 THEN SC=2:RETURN
5320  PRINT "[CD]...KILLING THE CREATURE"
5330  EX=EX+U:CF=0:SC=1:RETURN


5399  REM ** SPELL 3 (CRISPIT)
5400  IF PS<77 OR EX<5000 THEN SC=4:RETURN
5410  C=C-20:IF C<=0 THEN SC=5:RETURN
5420  PRINT D$;"WITH THE MIGHT OF MY SWORD I SMITE THEE"
5430  PRINT "WITH THE POWER OF MY SPELL I CURSE THEE"
5440  PRINT "BURN YE SPAWN OF HELL AND SUFFER..."
5450  DF=240:GOSUB 36000:REM ** DELAY + UPDATE
5460  PRINT D$;"A BOLT OF ENERGY LASHES AT THE BEAST..."
5470  DF=80:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
5480  IF RND(TI)>(PS/780)*(5-P1) THEN PRINT D$;"MISSED
      IT !":SC=2:RETURN
5490  D=INT((CS+PS*RND(TI))-(10*N*RND(TI)))
5500  IF D<=0 THEN D=0:SC=7:RETURN
5510  IF MS=0 THEN N=N-D:GOTO 5530
5520  MS=MS-D:IF D>10 THEN N=INT(N-(D/3))
5530  PRINT D$;"IT STRIKES HOME CAUSING ";D;" DAMAGE
      [2 SPC]!"
5540  IF (MS+N)<=0 THEN 5570
5550  DF=80:DL$="D":GOSUB 36000:REM ** DELAY
5560  SC=2:RETURN
5570  PRINT "[CD]THE BEAST DIES SCREAMING !"
5580  EX=EX+U:CF=0:SC=1:RETURN
```



Scene Control

Having drawn the Valley, the Path and the scenario positions, our hero is now free to wander where he chooses. A monster may kill him but with a little luck and fast reflexes, he will sooner or later enter one of the scenarios, or having entered may wish to escape!

To do this he simply moves onto the scenario or exit symbol. The part of the program concerned with movement, lines 2000-2240, detects the symbol and the program is directed to Scene Control at line 9000 or Scene Exit at line 9090.

A check is made at line 9000 to see if you are attempting to enter one of the secondary scenarios direct from the water, POKE code 224. If you are, the program is directed back to Movement via line 9110 which inhibits the turn count and the stamina refresh.

The two scene building arrays, P() and N(), are dealt with in lines 9010-9050. Array P() is used to fix the pattern of rooms on different levels of a scenario and if the scenario has more than one level, each level retains the same room pattern while you remain in that scenario. Array P() has all previous values zeroed.

Array N() has a series of random numbers, integers between 4 and 8, assigned to it (5 is not permitted as it can produce an unacceptable pattern). This array determines the depth of the rooms in the primary and secondary castle-type scenarios. Vounim's Lair and the Temple of Y'Nagioth (pronounced Ee-nag-ee-oth).

Entering a scenario, tested for in line 9060, from the Valley, MP is assigned your last position in the Valley, M, so that when you leave the scenario you will return to the same position.

A random integer between 1 and 30 is generated in line 9070 and is assigned to P(2). This is used in all scenarios to determine the position of lakes or the patterns of rooms. Line 9080 sets a temporary variable TF to the number of turns you have had so far, TN. This is then used when you try to exit from a scenario testing whether you have been 'in' for a certain number of turns. The line then directs the program past the initial portion of the 'scene exit' to line 9130.

Moving on to line 9090, a test is made to see if you have remained within a scenario for a minimum amount turns. Thus if the turns count is equal to or larger than the generated random number, the program jumps to line 9130. If not, you are barred from exiting the scenario and line 9110 inhibits the turns count and the stamina refresh. The program is then directed back to the Movement routine at line 9120.

With the Valley still displayed on the screen, line 9130 POKEs a space into your present position and POKEs your character symbol to the position of the scenario symbol, W is the position you are about to go to....

The lines 9140-9220 check to see what scenario or exit symbol has been stepped on thus determining the scene change required; Q1 represents the POKE code of position W.

If the symbol which frames the Swamps or Woods is found, for the PET we use a shifted space...POKE code 96, as specified in line 9140, then you must be leaving the scene and entering the Valley, S=1:F1=1. Line 9150 detects gateways, Q1=104, in the Black Tower, S=4, denoting that you are leaving the Tower and entering the Valley.

If a gateway is detected in the Temple, S=5, or the Lair, S=6, line 9160 directs the program to allow you to enter the Swamps, S=2, or the Woods, S=3, respectively. These secondary scenarios are only found on a lake in these scenarios but in both cases the scene number of the Swamps or Woods is 3 below their secondary scenarios, S=S−3. FL is determined in a similar manner, FL=FL−4, and your position in the Swamps or Woods is reset to your original position outside the secondary scenario, M=MW.

A check is made at line 9170 to see if you have entered the Swamps, setting the scene number, S=2, and the level , FL=2, if you have.

Another check is made at line 9190 for either Swamps or Woods to assign two string variables, D2$ and R2$, if either of these scenarios are entered. Both D2$ and R2$ are cursor control movements: D2$

being a random number of Cursor Downs between 0 and 9 and R2$ being a random number of Cursor Rights between 1 and 30; this is the first use of P(2).

In line 9210, there is a check for one of the secondary scenarios in the Swamps or the Woods. If the Lair or Temple symbol, POKE code 230 is recognised, the appropriate scene number is assigned S = S + 3 and level number FL = FL + 4. The temporary position variable, MW, is assigned your position, M, immediately prior to entering the secondary scenario.

The program is directed to the appropriate subroutine is line 9220 and then in line 9230, the program is directed to the delay and status update subroutine. On RETURNing, line 9240 takes you back to the Movement routine and the new scenario is displayed awaiting further exploration.

To give the maximum variety of scenes for the minimum amount of memory space used we chose, for the 16K game, two primary scenarios in addition to the Valley itself. We then used variations of these basic scenarios to provide additional areas to explore. **PF**

```
8999  REM ** SCENARIO CONTROL ROUTINE
9000  IF Q1=230 AND PK=224 THEN PRINT D$;"YOU CANNOT
      ENTER THIS WAY...":GOTO 9110
9010  FOR I=2 TO 7
9020  P(I)=0
9030  N(I)=INT(RND(TI)*5+4)
9040  IF N(I)=5 THEN 9030
9050  NEXT I
9060  IF S=1 THEN MP=M
9070  P(2)=INT(RND(TI)*30+1)
9080  TF=TN:GOTO 9130
9089  REM ** EXIT FROM SCENARIO
9090  IF TN>TF+INT(RND(TI)*6+1) THEN 9130
9100  PRINT D$;"THE WAY IS BARRED"
9110  TN=TN-1:C=C-10:DF=100:DL$="W":GOSUB 36000:
      REM ** DELAY + WIPE
9120  GOTO 2010
9130  C=C-10:POKE M,32:POKE W,Q
9140  IF Q1=96 THEN S=1:FL=1
9150  IF Q1=104 AND S=4 THEN S=1:FL=1
9160  IF Q1=104 AND S=5 OR S=6 THEN S=S-3:FL=FL-4:M=MW
9170  IF Q1=173 THEN S=2:FL=2
9180  IF Q1=216 THEN S=3:FL=3
9190  IF Q1=216 OR Q1=173 THEN D2$=LEFT$(D$,INT(RND(TI)*
      10)):R2$=LEFT$(R$,P(2))
9200  IF Q1=87 THEN S=4:FL=2
9210  IF Q1=230 THEN S=S+3:FL=FL+4:MW=M
9220  ON S GOSUB 10000,12000,12010,14000,14010,14010
9230  DF=5:GOSUB 36000:REM ** DELAY + UPDATE
9240  GOTO 2000:REM ** MOVEMENT
```

The Valley

Let us start where our 'alter ego', whatever his character type, will step out into his adventure... the Valley. Line 10000 clears the screen, sets F$ to 'VAEGH' which determines what monsters may be found in the Valley, ie monsters from groups V,A,E,G, and H (see Table 1). The difficulty level is set to 1 (FL has a bearing on how strong the monsters are) and finally sets the scene number also to 1 ...the Valley.

First let us draw the bounds of the Valley, this consists of a rectangle 39 characters wide by 14 characters high. Lines 10010 and 10050 draw in the top and bottom frames of the Valley, between them a FOR...NEXT loop draws the vertical frames consisting of the appropriate characters separated by 37 spaces. These are drawn 12 times giving an internal playing area of 37 x 12.

Line 10070 determines the position, M, of the left-hand safe castle, 32809 is the screen map position of the top left-hand corner of our frame.

Line 10080 assigns the position and character code for the left-hand safe castle to array elements G(0) and G(1) respectively. L and MP are temporary position variables. M is used throughout as your position ***now*** and W is your position when you next move (the look-ahead variable). All are set to position of the safe castle.

We now have to work out the course of the path; for the PET we use the two diagonal lines, POKE codes 77 and 78 (suggested symbols for other micros are given in Table 3). Using only these two symbols for the path enables us to make a fairly simple decision on how the path may be drawn:

1) If the path is already slanting up to the right then only two possibilities are acceptable; upwards to the North East or a downwards to the East (remember the path must be continuous).

2) If the path is already slanting down to the right then only downwards to the South East or upwards to the East are permissible.

The choice of an upwards or downwards diagonal is made randomly in line 10100. Lines 10110 and 10120 initially set the POKE code, PC, for a downwards diagonal to be to the South East of the present path (L1 = L + 41) and for an upwards diagonal to be to the North East (L1 = L − 39). L1 is a temporary position variable.

In line 10130 we check to see if the path is trying to go through the top or bottom frames of the Valley. If it is, the program is directed back to line 10100 to choose again. If it is within the Valley, we allocate in line 10140 an element of array G() to the POKE code for that section of the path. Looking back to 1) and 2) above, you will notice that if the next path element is different to the previous element it ***must*** always be to the East. This condition is checked in line 10150 and the temporary variable, L1, is altered if necessary.

Line 10160 stores the position of the path in array G(), assigns the starting position for the next section of the path to variable L and draws the section just computed on the screen.

This selection of path direction and position is repeated 36 times within a FOR...NEXT loop. Positions 1 and 37 are safe castles from which you may leave the Valley if you so wish. Even elements of G() are screen positions and odd elements are POKE codes for the safe castles or the path. Line 10180 completes the 'path draw' by placing the right-hand safe castle on the last path position.

Going back to line 10060 we see that this tests to see if the path has already been computed. If it has not then G(0) will be zero. If it has, the program skips the path computation and jumps to line 10190 which initiates a FOR...NEXT loop that draws the path using the information stored in array G(). In fact if the path is being drawn for the first time (on entering the Valley) it is also redrawn in lines 10190 to 10210.

Having drawn the Valley path we now have to work out where the different scenarios are to be placed within the Valley. These positions are stored in array S(). Line 10220 checks if they have already been assigned and if they have, the program jumps to line 10280 where the scenarios are drawn on the map of the Valley.

Line 10240 generates two random numbers that represent row and column positions within the

Valley. Line 10250 assigns this position to an element of array S(). Line 10260 checks to see that the chosen position and the position immediately to its right are not the path or safe castle (ie an empty space POKE code 32). If the positions chosen are free then the selection is repeated for the next element of array S().

Lines 10280-10300 POKE the scenario symbols on the screen. There is a chance that some symbols may be overwritten by other scenarios but then this is the luck of the draw! Woods are drawn first (code 216) then Swamps (code 173) and finally the Black Tower of Zaexon (pronounced Zeeks-on), code 87. Woods and Swamps are represented by two symbols side by side and both scenarios are repeated. The Black Tower is a single symbol; only one such Tower is found in the Valley.

Line 10310 assigns your present position to that of temporary variable, MP. This is used to remember your last position in the Valley when you return to the Valley from one of the other scenarios. **PF**

```
 9999  REM ** SCENARIO 1 (THE VALLEY)
10000  PRINT "[CLS]":FS="VAEGH":FL=1:S=1
10009  REM ** DRAW THE VALLEY FRAME
10010  PRINT "[HOM][REV][39^V][OFF]"
10020  FOR I=1 TO 12
10030  PRINT "[REV][^V][OFF][37 SPC][REV][^V][OFF]"
10040  NEXT I
10050  PRINT "[REV][39^V][OFF]"
10059  REM ** IF PATH ALREADY DRAWN SKIP
10060  IF G(0)<>0 THEN 10190
10069  REM ** COMPUTE THE PATH
10070  M=32809+(INT(RND(TI)*11+1)*40)
10080  L=M:MP=M:W=M:G(0)=M:G(1)=219
10090  FOR I=2 TO 72 STEP 2
10100  IF RND(TI)>0.5 THEN 10120
10110  PC=77:L1=L+41:GOTO 10130
10120  PC=78:L1=L-39
10130  IF L1>=33286 OR L1<=32806 THEN 10100
10140  G(I+1)=PC
10150  IF I>2 AND G(I+1)<>G(I-1) THEN L1=L+1
10160  G(I)=L1:L=L1:POKE G(I),G(I+1)
10170  NEXT I
10180  G(73)=219
10189  REM ** PLOT IN PATH
10190  FOR I=0 TO 72 STEP 2
10200  POKE G(I),G(I+1)
10210  NEXT I
10220  IF S(0)<>0 THEN 10280
10229  REM ** COMPUTE SCENARIO POSITIONS
10230  FOR I=0 TO 4
10240  N1=INT(RND(TI)*11)+1:N2=INT(RND(TI)*34)+1
10250  S(I)=32809+(40*N1)+N2
10260  IF PEEK(S(I))<>32 OR PEEK(S(I)+1)<>32 THEN 10240
10270  NEXT I
10279  REM ** PLOT IN SCENARIOS
10280  POKE S(0),216:POKE S(0)+1,216:POKE S(1),216:POKE
       S(1)+1,216
10290  POKE S(2),173:POKE S(2)+1,173:POKE S(3),173:POKE
       S(3)+1,173
10300  POKE S(4),87
10310  M=MP:W=M
10320  RETURN
```

Woods And Swamps

These two scenarios are fundamentally the same, only the characters representing their contents and the special scene in the middle of the Lake differ. The starting point selected by the Scene Control routine is 12000 for the Swamp and 12010 for the Woods. The function of each of these entry points is to establish the valid monster string, F$, and to assign the POKE code, PC, to the correct value for the scene. The routine proper begins by re-assigning the POKE value of the square under your feet to 32, a space, so that when you move away you don't leave the character you were standing on in the Valley behind you.

The screen is now cleared in preparation for the construction of the scene. A pointer variable, L, is set to the value of the top left-hand corner of the scene and a random FOR...NEXT loop inserts 200 appropriate scene characters into the screen area. This is all handled by the block code from 12040 to 12070.

Having constructed the basis of the scenario we now need to plot in the Lake containing the secondary scenario and this is performed by the block code from 12080 to 12140. The values of D2$ and R2$ were previously determined in the Scenario Control section and serve to position the Lake within the scene area. The castle-type scene at the centre of the Lake is dependent on whether you are currently in the Woods, Vounims' Lair, or the Swamps, The Temple of Y'Nagioth.

Having now constructed the inside of the scene, we have to print a border around it in order to detect an attempt at movement outside the scene area. The border is printed by the section of program between 12150 and 12190 and is made up of non-32 type spaces on the PET, other suggestions are to be found in Table 3. Because the border is printed in after the scene has been constructed, it will overwrite any stray scene characters in the 1st and 40th column; this simplifies the random printing routine. The semi-colons at the end of of lines 12150 and 12170 ensures that the frame is continuous; printing into the 40th column would otherwise force a Carriage Return.

The next operation is to POKE a space character to the position in which the character will appear and assign W to the address of that position. This ensures that when you enter the Woods you are not completely hemmed in by trees; it doesn't matter in the case of the Swamps.

Because you could re-enter the Woods and Swamps from one of the secondary scenes, a check is made in line 12210 to see if the POKE code of the square you were standing on was a doorway. If it was, your current position is reset to the position you were in when you entered that secondary scene. The value of that position is then held in the variable MW and is assigned when you enter a secondary scene. **PF**

```
11999  REM ** SCENARIO 2 (WOODS AND SWAMPS)
12000  F$="AFL":PC=45:GOTO 12020
12010  F$="FAEHL":PC=88
12020  PK=32
12030  PRINT "[CLS]"
12039  REM ** DRAW RANDOM WOODS OR SWAMPS
12040  L=32810
12050  FOR I=1 TO 200
12060  POKE L+INT(RND(TI)*515),PC
12070  NEXT I
12079  REM ** PRINT IN LAKE
12080  PRINT "[HOM]";D2$;R2$;"[2 CR][REV][2 SPC][OFF]"
12090  PRINT R2$;"[CR][REV][5 SPC][OFF]
12100  PRINT R2$;"[REV][2 SPC][OFF][2 SPC][REV][2 SPC]
       [OFF]"
12110  PRINT R2$;"[REV][2 SPC][^&][OFF][SPC][REV][3 SPC]
       [OFF]"
12120  PRINT R2$;"[CR][REV][4 SPC][OFF][CR][REV][2 SPC]
       [OFF]"
12130  PRINT R2$;"[3 CR][REV][2 SPC][OFF]"
12140  PRINT R2$;"[4 CR][REV][SPC][OFF]"
12149  REM ** DRAW IN THE FRAME
12150  PRINT "[HOM][40^SPC]";
12160  FOR I=1 TO 13
12170  PRINT "[^SPC][38 CR][^SPC]";
12180  NEXT I
12190  PRINT "[40^SPC]"
12200  POKE 33306,32:W=33306
12210  IF Q1=104 THEN M=MW:W=M
12220  RETURN
```

The Black Tower

Our other primary scenario is the Black Tower of Zaexon. This is a six floor castle-type scene and its construction is also used to produce the secondary single floor scenes found in the Woods and Swamps. The Tower has a stable floor pattern; once a floor has been entered it will remain the same as long as you are in the Tower.

Scenario Control directs the program to the routine at 14000 assigning the monster string, FS; zeroing the floor pattern variable, P; and setting the room depth variable, H, to the current FLth element of array N(). The current position character is set to a space and the program jumps to 14020. The variables for the secondary scenes are initialised in 14010. One slight change is that the array P() is set to the value of P(2). This is done because the secondary scenes have initial FL values of 6 or 7 depending on type and these elements of P() are 0 which would cause the room pattern to be the same each time (see line 14070).

The frame of the Tower is printed first by lines 14020 to 14060 using a reversed space character (Table 3 holds alternatives for other systems). The vertical walls are drawn next by the somewhat complex routine found between 14070 and 14250. In order to ensure that the pattern of rooms varies on each floor and on each visit to the scene, we use the 31 element data statement at line 60000. These are READ sequentially for each new floor and represent the width of each room. To give variety to the pattern of rooms the starting point of the READ is determined randomly in the Scenario Control section and stored in P(2). To start the drawing sequence the DATA pointer is RESTOREd and then P(2) dummy READs are made; V is used only as a temporary store. Once again we use the pointer variable, L, to hold the address of the top left-hand corner of the scene. We now read the next three DATA items from the list and store them in array D(); the number of sets of 3 is stored in the temporary variable, P.

The actual drawing of the vertical walls is done by lines 14150 to 14240 and their length is dependent on the value of H, the room depth variable. The wall characters are POKEd into position as are the doors which occur a predetermined distance along them. Having drawn the first set of vertical walls the starting point is re-assigned in line 14250 and the next set is drawn in — this process is repeated until the walls have reached the bottom of the frame.

The horizontal walls can now be drawn in and their spacing is dependent on the value of the current element of array N(). The routine is located between lines 14270 and 14340.

As only the Black Tower has stairs, line 14350 causes the secondary scenes to skip over this section of the program. The Black Tower has stairs located in opposite corners for each floor and these are POKEd into position on lines 14360 and 14370. If you are on the ground floor of the Tower or in one of the secondary scenes, a doorway is POKEd into position by line 14380.

If you are stepping into the Tower or either of the secondary scenes for the first time, your character will be placed just inside the doorway; the check for this is made in 14390 as P(3) will only be 0 if you haven't gone up any stairs yet.

The appropriate name for the castle-type scene is PRINTed into position by lines 14400 to 14480 and, in the case of the Tower, the floor number is also displayed.

Treasure can be found in the upper floors of the Tower, and either of the two secondary scenes, provided the value of FL is equal to or greater than 4 ***and*** a random factor is greater than 0.3. If these conditions are not met, control returns to the Scenario Control section and then back to the Movement routine. If both conditions are met, a random number of special treasure symbols are displayed; between 2 and 6 can appear and are shown as asterisks. They are positioned by the two temporary variables N1 and N2 which act as row and column co-ordinates. Provided the position selected is vacant an asterisk is POKEd into place. **PF**

```
13999  REM ** SCENARIO 3 (CASTLE-TYPES)
14000  F$="CAGE":P=0:H=N(FL):PK=32:GOTO 14020
14010  F$="CBE":P=0:H=N(FL):PK=32:P(FL)=P(2)
14019  REM ** DRAW FRAME
14020  PRINT "[CLS][REV][2 CR][21 SPC][OFF]"
14030  FOR I=1 TO 13
14040  PRINT "[REV][2 CR][SPC][OFF][19 SPC][REV][SPC]
       [OFF]"
14050  NEXT I
14060  PRINT "[REV][2 CR][21 SPC][OFF]"
14069  REM ** DRAW VERTICAL WALLS
14070  RESTORE:FOR I=1 TO P(FL)
14080  READ V:IF V=100 THEN RESTORE
14090  NEXT I
14100  L1=32810
14110  FOR J=1 TO 3
14120  READ D(J):P=P+1
14130  IF D(J)=100 THEN RESTORE:D(J)=3:P=P+1
14140  NEXT J
14150  FOR I=0 TO H:PC=160
14160  L=L1+(40*I):IF L>33290 THEN 14260
14170  IF I=1 THEN PC=32
14180  IF D(1)=0 THEN PC=160:GOTO 14200
14190  POKE L+D(1),PC:PC=160
14200  IF I=3 THEN PC=32
14210  POKE L+D(1)+D(2),PC:PC=160
14220  IF I=4 THEN PC=32
14230  POKE L+D(1)+D(2)+D(3),PC:PC=160
14240  NEXT I
14250  L1=L1+(40*H)+40:GOTO 14110
14259  REM ** DRAW HORIZONTAL WALLS
14260  L1=32810
14270  FOR J=1 TO 4
14280  L=L1+(40*J*(H+1))
14290  FOR K=1 TO 19
14300  IF L>33250 THEN 14350
14310  POKE L+K,PC
14320  IF K=2 OR K=3*H OR K=17 THEN POKE L+K,32:
       POKE L+K-40,32:POKE L+K+40,32
14330  NEXT K
14340  NEXT J
14349  REM ** DRAW IN THE STAIRS
14350  IF S=5 OR S=6 THEN 14380
14360  IF FL/2=INT(FL/2) THEN POKE 33291,102:GOTO 14380
14370  POKE 32829,102
14379  REM ** DOORWAY NEEDED ?
14380  IF FL=2 OR S=5 OR S=6 THEN POKE 33336,104:
       POKE 33296,32
14390  IF P(3)=0 THEN W=33296
14399  REM ** WRITE APPROPRIATE NAME
14400  IF S=5 THEN 14470
14410  IF S=6 THEN 14450
14420  PRINT "[HOM]";R1$;"[4 CD][3 CR]THE BLACK TOWER"
14430  PRINT R1$;"[3 CR][3 SPC]OF ZAEXON"
14440  PRINT R1$;"[3 CD][3 CR][3 SPC]FLOOR ";FL-1:
       GOTO 14490
14450  PRINT "[HOM]";R1$;"[2 CD][5 CR][REV][SPC]
       VOUNIM'S[SPC][OFF]"
14460  PRINT R1$;"[5 CR][REV][3 SPC]LAIR[3 SPC][OFF]":
       GOTO 14500
14470  PRINT "[HOM]";R1$;"[2 CD][4 CR][REV]THE TEMPLE OF
       [OFF]"
14480  PRINT R1$;"[4 CR][REV][2 SPC]Y'NAGIOTH[2 SPC]
       [OFF]"
14490  P(FL+1)=P(FL)+P
14499  REM ** SCATTER SPECIAL FINDS
14500  IF FL<4 OR RND(TI)<0.3 THEN RETURN
14510  FOR I=1 TO INT(RND(TI)*5)+2
14520  N1=INT(RND(TI)*19)
14530  N2=INT(RND(TI)*12)
14540  IF PEEK(32811+40*N2+N1)<>32 THEN 14520
14550  POKE (32811+40*N2+N1),42
14560  NEXT I
14570  RETURN
```

Stairs

In the Black Tower each floor is connected to the next by a set of stairs. These are set at diagonally opposite corners of each floor and each stair operates only in one direction. This means that if you walk up one flight you have to cross the entire floor to reach the next set; you can't simply go down the flight you came up!

The routine is located from 15000 to 15110 and starts by offering you a choice of going either up or down. The character pressed is checked at 15030 to 15050 to see if it is valid and if it is, the FL variable is incremented. This value represents the floor to which you wish to move and checked by line 15060 to ensure that it is within limits. If the value of FL is outside the limits, a suitable message is printed and the current floor level reset into FL from the temporary variable TV. **HB**

```
14999  REM ** STAIRS ROUTINE
15000  POKE W,81:POKE M,32
15010  PRINT DS;"A STAIRWAY...
       UP OR DOWN ?":TV=FL
15020  VG$="UD":GOSUB 1500:
       REM ** UNIGET
15030  IF GC$="U" THEN FL=FL+1:
       GOTO 15050
15040  FL=FL-1
15050  IF FL>7 OR FL<2 THEN 15080
15060  DF=110:DL$="D":GOSUB 36000
15070  GOTO 9220
15080  PRINT D$;"THESE STAIRS
       ARE BLOCKED[SPC]"
15090  DF=60:DL$="D":GOSUB 36000:
15100  FL=TV:GOTO 15010
```

Delays

The routine from 36000 can be broken down into three functional blocks; delay, wipe and update. All calls to the routine are first set up by defining the contents of the variable DF which controls the length of the delay. If only the delay section of the routine is required then a flag variable, DL$, is set to "D" to indicate this; the test in line 36020 causes an early RETURN.

In cases where a message wipe is needed after the delay but no update is required, the flag is set to "W" which forces a RETURN at line 36060. The wipe is simply performed by overwriting the text area with spaces.

The rest of the routine is concerned with updating the adventurer's status on the screen. Before the data is printed it is checked to see if it has reached or exceeded the maximum for the current character type, see Table 2. The code that performs these checks can be found in lines 36070 to 36100. The variables for experience, treasure and turns, can only increase so these are simply overprinted in line 36120 to 36140. The value of combat strength, psi power and stamina can decrease as well as increase so these are first erased and then reprinted; lines 36150 to 36170 perform this task.

If a combat is in progress the flag variable, CF, is set to 1 and this is tested for in 36180. If it is set, the monster's current status is also updated at line 36210 and 36220. If, however, the flag is cleared to show that no combat is taking place, the line of the screen where this information would normally occur is wiped clean.

HB

```
35999  REM ** DELAY, WIPE & UPDATE ROUTINE
36000  FOR DL=1 TO (DF*TM)
36010  NEXT DL
36020  IF DL$="D" THEN DL$="":RETURN
36030  PRINT D$;SP$
36040  PRINT SP$
36050  PRINT SP$
36060  IF DL$="W" THEN DL$="":RETURN
36070  IF CS>77-INT(2*P1^2.5) THEN CS=77-INT(2*
       P1^2.5)
36080  IF PS<7 THEN PS=7
36090  IF PS>INT(42*(P1+1)^LOG(P1^3.7))+75 THEN
       PS=INT(42*(P1+1)^LOG(P1^3.7))+75
36100  IF C>125-(INT(P1)*12.5) THEN C=125-INT(INT(P1)*
       12.5)
36110  PRINT D1$;"[CU]";J$,P$
36120  PRINT "TREASURE   =";TS
36130  PRINT "EXPERIENCE =";EX
36140  PRINT "TURNS      =";TN
36150  PRINT D1$;R1$;"COMBAT STR =[4 SPC][4 CL]";CS
36160  PRINT R1$;"PSI POWER  =[4 SPC][4 CL]";PS
36170  PRINT R1$;"STAMINA    =[4 SPC][4 CL]";C
36179  REM ** IF FIGHTING UPDATE MONSTER
36180  IF CF=1 THEN 36210
36190  PRINT SP$
36200  RETURN
36210  PRINT D$;[2 CU][REV]";MS;"[OFF]";
36220  PRINT D$;R1$;"[2 CU]M STR =[12 SPC][12 CL]";MS;N;
       "[4 SPC]"
36230  RETURN
```

Ratings

The ratings system used in the Valley program is based on a character achieving the maximum rating of 28, Master of Destiny, only after amassing 200,000 experience points.

Assigning a rating of 7 to an experience of 10,000 and a rating of 20 to 50,000 experience, the plotted curve began to show definite parabolic tendencies. After experimenting with the general equation of a parabola, $y^2 = 4ax$ or $y = c\sqrt{x}$ (where c is a constant), no simple values were found to fit. So...we compromised! Using the formula, $y = 0.067\sqrt{x}$, we managed to get y values of 6.7 for an x value of 10,000, 15 at 50,000 and 28 at 200,000.

Realising that the rating should be based on experience and treasure, the x factor was defined as $x = EX + TS/3$. Then, in an attempt to penalise cowardice and rewarding those taking risks, a second factor, $\log (EX/(TN + 1)\uparrow 1.5))$, was added taking the number of turns to acquire your experience into the final equation. **HB**

RATING	CLASSIFICATION
1	Monster Food
2	Peasant
3	Cadet
4	Cannon Fodder
5	Path Walker
6	Novice Adventurer
7	Survivor
8	Adventurer
9	Assassin
10	Apprentice Hero
11	Giant Killer
12	Hero
13	Master of the Sword
14	Champion
15	Necromancer
16	Loremaster
17	Paladin
18	Superhero
19	Dragon Slayer
20	Knight of the Valley
21	Master of Combat
22	Dominator
23	Prince of the Valley
24	Guardian
25	War Lord
26	Demon Killer
27	Lord of the Valley
28	Master of Destiny

Left: The rating numbers and their corresponding classifications.

```
44999  REM ** RATING ROUTINE
45000  DF=5:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
45010  RT=INT(0.067*(EX+TS/3)^0.5+LOG(EX/((TN+1)^1.5))):
       IF RT>28 THEN RT=28
45020  IF RT<0 THEN RT=0
45030  PRINT D$;"YOUR RATING NOW BE";RT
45040  IF T(2)=1 THEN PRINT "YOU HAVE THE HELM OF EVANNA"
45050  IF T(0)=1 THEN PRINT "AMULET STONES...[SPC]";T(1)
45060  DF=250:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
45070  IF GC$="E" THEN C=C-10:GC$="":GOTO 2010:
       REM ** MOVEMENT
45080  RETURN
```

Quit

If the adventurer steps on either of the two safe castles, one at each end of the path, he is offered the option of leaving the Valley. Regardless of his selection, his current rating is also computed and displayed at this point. If the player chooses to leave the Valley by keying "Y", control is passed to the Save routine at line 50000.

Because the castle is safe the player's character is 'healed' of his wounds and readied for the Valley once more. This healing consists of resetting the stamina to its maximum value and ensuring a minimum combat strength of 20. **HB**

```
47999  REM ** QUIT VALLEY ROUTINE
48000  PRINT D$;"THOU ART SAFE IN A CASTLE":IF CS<20 THEN
       CS=20
48010  POKE M,PK:PK=PEEK(W):M=W:POKE M,Q
48020  PRINT "WILT THOU LEAVE THE VALLEY (Y/N) ?"
48030  VG$="YN":GOSUB 1500:REM ** UNIGET
48040  DF=5:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
48049  REM ** GENERATE RATING IN CASE OF SAVE
48050  GOSUB 45000:REM ** RATING
48060  DF=110:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
48070  IF GC$="Y" THEN 50000:REM ** SAVE ROUTINE
48080  C=150:PRINT D$;"THY WOUNDS HEALED...THY SWORD
       SHARP"
48090  PRINT "GO AS THE GODS DEMAND..TRUST NONE OTHER"
48100  DF=120:GOSUB 36000:REM ** DELAY + UPDATE
48110  GOTO 2010:REM ** MOVEMENT


49999  REM ** SAVE CHARACTER ROUTINE
50000  PRINT "[CLS]DO YOU WISH TO SAVE ";J$;" ?"
50010  PRINT:PRINT "PLEASE KEY Y OR N"
50020  VG$="YN":GOSUB 1500:REM ** UNIGET
50030  IF GC$="N" THEN 50210
50040  PRINT "[CLS]PLACE YOUR CASSETTE IN THE TAPE DECK"
50050  PRINT "IS IT REWOUND ?"
50060  GOSUB 1600:REM ** ANYKEY
50069  REM ** THIS IS FOR PET ONLY
50070  OPEN 1,1,1,J$
50080  PRINT#1,P$
50090  PRINT#1,T$
50100  PRINT#1,EX
50110  PRINT#1,TN
50120  PRINT#1,CS
50130  PRINT#1,PS
50140  PRINT#1,T(0)
50150  PRINT#1,T(1)
50160  PRINT#1,T(2)
50170  PRINT#1,C1
50180  PRINT#1,P1
50190  CLOSE 1
50200  PRINT "[CLS][3 CD]"," *** DONE ***"
50210  PRINT D$;"[6 SPC]TYPE RUN TO START AGAIN"
50220  CLR
50230  END


54999  REM ** DEATH ROUTINE
55000  C=0:CS=0:PS=0:CF=0
55010  DF=110:GOSUB 36000:REM ** DELAY + UPDATE
55020  IF T(1)=6 THEN 55070
55030  PRINT D$,"[CR]OH WHAT A FRAIL SHELL"
55040  PRINT,"[2 CR]IS THIS THAT WE CALL MAN"
55050  DF=300:DL$="W":GOSUB 36000:REM ** DELAY + WIPE
55060  PRINT "[CLS]":GOTO 50210
55069  REM ** RESTORE CHARACTER TO LIFE
55070  T(0)=0:T(1)=0:TS=0:CS=30:C=150:PS=30
55080  PRINT D$;"ALARIAN'S AMULET PROTECTS THY SOUL"
55090  PRINT "[CD][REV][2 SPC]LIVE AGAIN[2 SPC][OFF]"
55100  DF=150:GOSUB 36000:REM ** DELAY + UPDATE
55110  L=G(0):MP=L:M=W:S=1:GOTO 9220:REM ** SCENE CONTROL


59999  REM ** DATA FOR CASTLE TYPE SCENARIOS
60000  DATA 4,7,3,6,4,4,6,5,3,6,3,3,8,4,3,5,5,3,
       8,3,4,5,0,6,3,3,8,8,4,7,4,100
60009  REM ** DATA FOR MONSTERS
60010  DATA AWOLFEN,9,0,AHOB-GOBLIN,9,0,AORC,9,0,
       EFIRE-IMP,7,3,GROCK-TROLL,19,0
60020  DATA EHARPY,10,12,AOGRE,23,0,BBARROW-WIGHT,0,25,
       HCENTAUR,18,14
60030  DATA EFIRE-GIANT,26,20,VTHUNDER-LIZARD,50,0,
       CMINOTAUR,35,25,CWRAITH,0,30
60040  DATA FWYVERN,36,12,BDRAGON,50,20,
       CRING-WRAITH,0,45,ABALROG,50,50
60049  REM ** SPECIAL MONSTERS FOR WATER ONLY
60050  DATA LWATER-IMP,15,15,LKRAKEN,50,0
```

Save

Stepping on one of the two safe castles is the only way to leave the Valley in an upright position as the option to save your character on tape is then offered. Taking this option out of the Quit routine passes control to the Save routine at 50000. The lines of code between 50070 and 50190 are specific to the PET and should be replaced with the corresponding code for whatever system you are implementing the game on.

At the end of this routine, whether you reach it by saving the data on tape or by choosing not to save in the Quit routine and dropping through, all the current variables are cleared and a farewell message displayed. **HB**

Death

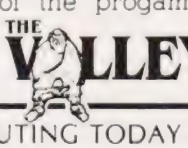
This routine is the one part of the program the player would rather not have executed! Many and varied are the ways in which one can arrive at line 55000 and on all but one occasion the outcome is inevitable. The one exception is when you have been fortunate enough to collect the Amulet of Alarian and filled it with the six missing stones because this gives you a second life.

The test to see if you have the Amulet and its stones is made at 55020 and if successful you are restored to life. The price is, however, high as you lose all your treasure together with the Amulet and its stones. Your combat strength and your psi power are both set to 30; the only value that remains the same after death is your experience. The Valley is now redrawn and the character starts from the initial position once again.

If, as is most likely the case, you don't have the protection of the Amulet and its six stones then the game ends with all the variables being zeroed in line 50220. **HB**

Data

Rather than placing each data block with its relevant routine we have chosen to lump it all together at the end of the program. The first block contains all the information needed to build the three castle-type scenarios (see the relevant sections for more details on this). The second block of data holds the monster information which is READ into the three arrays M$(), MS() and N1() at the start of the 'progam. **HB**



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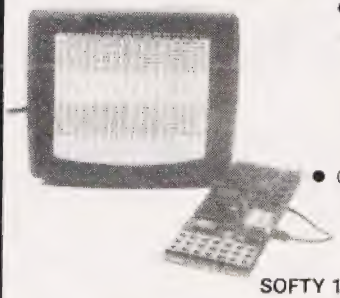

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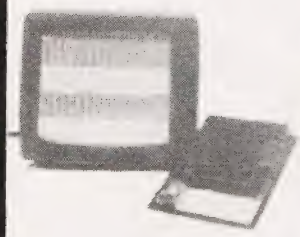

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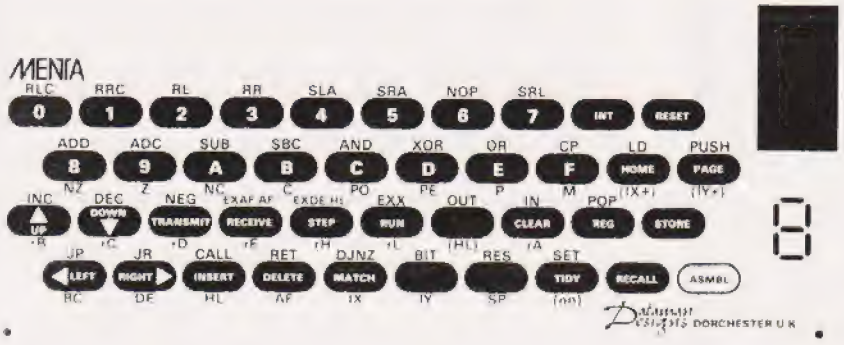

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- INTERRUPT key which stops a running program to permit examination of registers and stack.
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Mike James

TANDY COLOR REVIEWED

In producing their 6809-based Color Computer, Tandy seem to have broken away from their established markets and gone for a truly domestic system. We take a look inside.

A few years ago I doubt that anyone would have thought that Tandy (known as Radio Shack in the States) would sell computers — IBM sold computers. Now however, Tandy sell one of the most popular computers in the world and their brochures offer a full range of machines with backup peripherals. Such is the way the microprocessor has turned things upside down!

Tandy began business by selling electronic components, kits and the like before moving up to 'own' brand electronic equipment such as tape recorders and amplifiers. They established a very successful chain of stores in the USA each offering the same range of products. In the UK the picture has been very different and only recently has the name Tandy become familiar in every (?) High Street along with you-know-who's fried chicken, another franchised success!

After their slow start, Tandy now offer a range of Z80-based systems starting with the well known Model I (***the*** TRS-80) and finishing with either the Model II (built-in 8" discs) or the Model III (optional built-in 5¼" discs) depending on how you look at it. All of the machines in this range are fairly straightforward Z80 machines with Microsoft BASIC and medium resolution block graphics — the sort of thing that's just right for 'serious' computing. However, Tandy do make another machine that's ***very*** different — the TRS-80 Color Computer.

The most obvious difference between it and the rest of the range is evident in the title — it's got high resolution colour graphics. Yet almost as important is the fact that it doesn't use a Z80 but a 6809 and this is slightly (!) obscured by the 80 in TRS-80. If it were only for the colour graphics and the 6809, the Color Computer would be an interesting machine but there are lots of other features that make this machine exciting.

From the point of view of the user it offers: sound effects over the TV set; joystick inputs as standard; and plug-in ROM cassettes for 'instant' program loading as well as the aforementioned colour graphics with up to eight colours. Looking at it from the technical minded enthusiast's angle (that is anyone reading CT), the Color Computer is fascinating — it uses a basic design likely to be new to most people and provides a great deal of flexibility if you want to try out new things. Tandy, quite logically, see their Color Computer as a potential competitor in the low-cost games machine market and their advertising and range of extras and add-ons supports this view. However, because of its remarkable hardware, other people have become so keen that all sorts of other uses have been thought up for it and many of these fall into the 'serious' computing category — so the wheel turns full circle.

An Overview

The Tandy Color is self-contained — apart from the need for an external cassette unit and a TV set that is. In size it resembles a portable typewriter and is unusually light for a personal computer. It has a largish flat area to the rear of the keyboard that might be suitable for standing peripherals such as 5¼" disc drives (see later) but is a bit on the small size for a black and white TV and a colour TV would certainly make it flatter!

The keyboard is probably the most controversial feature of the Color Computer being made up of square cut push switches with large gaps between. In practice the difference is more one of appearance than function. The layout is QWERTY and the distance between the centre of the keys is actually no larger than a 'normal' keyboard, but I suppose that some people will find it unacceptable. Personally I wouldn't like to type very much text on it but it all depends what you're used to.

The screen text display consists of a miserly 16 lines of 32 characters and they are all UPPER CASE. This may be good enough for playing games but it is a distinct disadvantage when it comes to any serious application such as text processing or education. To be strictly accurate the keyboard can generate lower case and the Color Computer can display them — as reversed colour upper case letters! There really isn't much excuse for a machine not to have proper lower case these days.

Apart from the keyboard and the screen text display the Color Computer is a good machine to use. The colour graphics are convincing — ie, the colours are distinct and clear — but many of the graphics modes are only available in the 32K machine so make sure that you buy a system that's big enough. One disadvantage of the hi-resolution graphics modes is the difficulty of mixing text and graphics. To go with the colour is a sound generator which, according to the advertising, can 'produce 255 separate tones' but only one at a time. This means that playing chords is difficult to say the least (see later for more technical information). One feature of the sound generator that I liked was the way it was fed to the TV with the video signal. Having the 'bleeps and squeaks' coming from the TV where all the action is happening is much more satisfying than having them coming from a little box or from inside the keyboard.

The cassette interface is not bad for short term use but I found it level sensitive — use a good recorder and stick to it. Perhaps the presence of a cassette storage device isn't so important for the Color Computer because of its ability to accept 'Program Paks'. These are small (5" x4" x 1") plastic boxes that can be plugged into the side of the machine to effectively load a program in no time at all. You simply switch the computer off, plug the Pak in and switch the machine back on. If all goes as it should the program contained in the Pak will begin to run immediately. There are problems with this method of program loading, however. First you have to remember to switch off before you insert or remove a Program Pak — Tandy don't tell you what might happen if you forget but it's likely to be destructive! Second, on the review machine at least, inserting the Pak was quite difficult and removing some of them proved impossible; I actually had to open the machine to remove one of them! I'm not saying that all Color Computers behave this way, at least ***one*** does, so ask for a repeated demonstration with a number of Paks to check this point before you part with your money.

If you can master the insertion and removal of Program Paks you will be rewarded by a range of software that includes some very good games. These range from Chess to Project Nebula, a 'fly your space ship and shoot the enemy' simulation that gives a very good impression of what you might see through a spaceship's cockpit window! The trouble is that they are not cheap; Chess is priced at £26.95 and Project Nebula at £25.95.

The Hardware

The case of the Color Computer is 3.5" x 13.75" x 14.75" and is made of a reasonable quality silver-grey plastic. Some parts of the case are thin and rely on internal pillars or the keyboard for support! This would only cause a problem if you dropped something heavy on it ... and you wouldn't do that would you! Cooling is by convection and ventilation slots can be found across the top and bottom of the machine — usual comments about keeping them unobstructed apply. Opening the case is easy — although I get the impression that Tandy would rather you didn't know this — just undo all the screws in the bottom, including the one hidden by the 'opening the case will void guarantee' sticker and lift the top off.

Inside you find that the construction is simple — only two items: the keyboard and the main PCB.

The Keyboard The construction of the keyboard is remarkable! It's completely enclosed by a moulded plastic trim and instead of needing support, it could easily provide it! I didn't have enough courage to loosen the 21 small screws on the base to find out what sort of key caps would have fallen into my lap ... the risk didn't seem worth it! I've already made comments about the keyboard in use so I'll simply add that there is no shift or caps lock key (although a shift lock is generated by pressing shift and 0) and there is no 'ctrl' key — so if you want to use the Color Computer as a smart VDU you will have to provide one in software.

The Main PCB Just about everything comes under this heading because Tandy managed to get everything — including the power supply — on one circuit board.

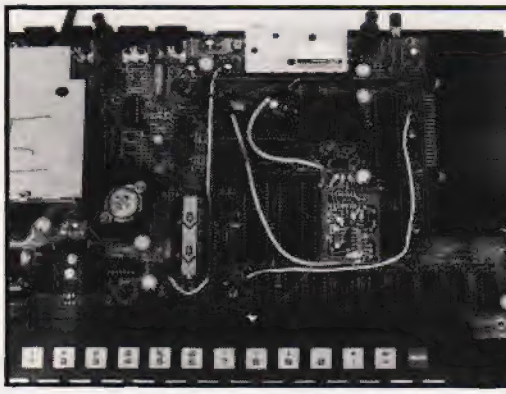
The power supply is of an unspecified type but is claimed to be less than 50 W rating. This is certainly borne out by the small size of the transformer. The rest of the circuit seems to be a straightforward bridge rectifier regulator configuration giving the usual +5, −5, +12, and −12 V. There are no problems here — it runs cool and all the regulators that need it are fixed to heavy heatsinks.

A large area of the main board is covered by a metal box, the lid of which can be removed by cutting two cable ties. This box has two uses — it cuts down radio interference and stops you inspecting the interesting part of the circuitry! If you do remove the lid of the screening you will be surprised by how few chips are hidden under it, a good proportion of which are 40-pin LSI devices. Because of the fairly small number of devices the board is well laid out with plenty of space between chips — in fact I don't think I've ever seen so much space between memory chips!

Having praised the overall layout of the main PCB it is sad to have to report that the metal screening also hides a terrible mess of jumper wires, components soldered directly to the pins of socketed chips and a small 'piggy-back' board. On the review machine the quality of the 'extra' soldering was poor — it's not easy to solder small components across the pins of an installed integrated circuit without damage!

Above: Plugging in the Program Paks requires care — they can sometimes jam.

Below: Tandy have hidden their PAL conversion under a metal lid, possibly in shame!



This sort of mess can only serve to lower the reliability of the machine and is likely to introduce intermittent faults visible on the TV screen. By tracing wires and making educated guesses I would say that the modifications are to do with converting the USA NTSC colour signal to a UK PAL colour signal. If this is true it indicates that the UK market was far from Tandy's mind when designing the Color Computer and that they have taken an easy route to producing the UK model. No matter what the reason for the 'extra' electronics — it is not an impressive sight!

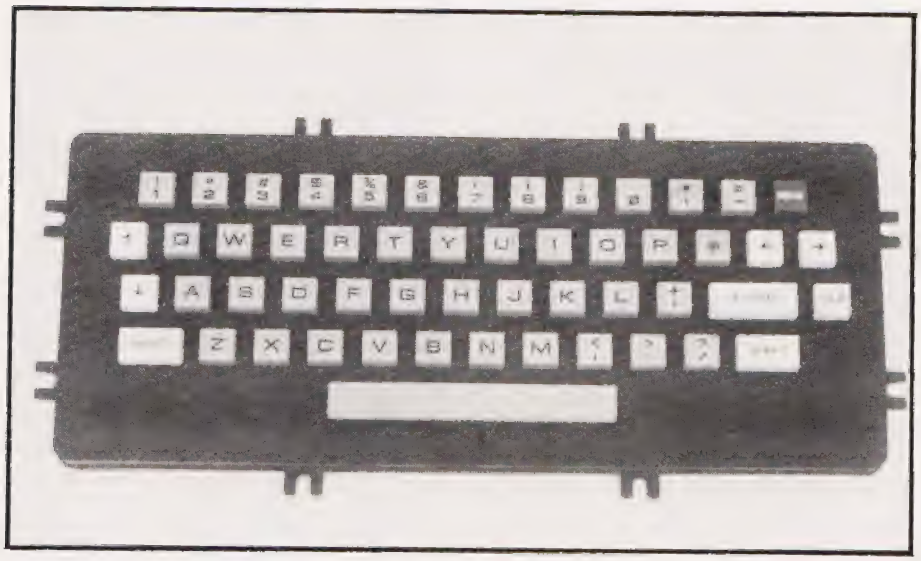
New Technology

It's a shame about the multilation of the main logic board because the circuitry it holds is very clever stuff. As I've already mentioned the microprocessor is a 6809 made by Motorola — in fact every chip in the Color Computer is made by Motorola so I won't bother saying it again! The 6809 is thought by many, myself included, to be the best microprocessor currently available apart from the 68000. It is an eight-bit processor with 16-bit internal registers and a wide range of easy to use, yet powerful instructions.

TANDY COLOR REVIEWED

Right: Neat connections at the rear typify the clean lines of the system's packaging.

Below: Although it looks slightly odd the keyboard does use the standard QWERTY layout.



Apart from using an advanced microprocessor the Color Computer uses two other newish devices, the MC6883 Synchronous Address Multiplexer (or SAM) and the MC6847 Video Display Generator (or VDG). The SAM is a very clever device that 'looks after' the memory for the 6809. It generates clock signals and the necessary refresh signal for dynamic RAM, allows bank switching between two 32K pages of RAM and a variable clock rate to allow slow RAM and fast ROM to be used. In addition to all this it interfaces the VDG to the memory in such a way that the 6809 and the VDG share the memory without any loss of speed. In fact the SAM and the VDG are 'locked' together in the sense that they share the same clock signals and the same operating mode. The VDG has no direct control over the memory, it is only connected via the data bus. The SAM, knowing which display mode the VDG is working in, produces the appropriate address at the right time to deliver the correct piece of data to the VDG for display. This is very different from the way most video generators work; normally both the data and address lines are shared by the microprocessor and the video generator — this causes timing problems and only allows one area of memory to be treated as the 'screen'. Using the combination of the SAM and the VDG we can allow the SAM to resolve any timing conflicts and also choose the area of memory that will be delivered to the VDG for screen display. This last feature makes a certain amount of animated graphics possible by drawing a number of pictures at various places in memory and switching the display area from one to another.

The VDG itself is capable of a wide range of display modes the most important are:

MODE	GRID SIZE	COLOURS	PAGES
Text	32x64	8	1
0	128x96	2	1
1	128x96	4	2
2	128x192	2	2
3	128x192	4	4
4	256x192	2	4

Text mode provides a TRS 80 compatible SET/RESET style of graphics. The amount of memory each mode uses is given in pages or blocks of 1.5K. You can see how the display memory is allocated from the memory map.

The 16 or 32K of RAM is provided by a row of eight dynamic RAM chips. The ROM memory is in the form of two 8K chips and there is no room for any more on the main PCB. Of course this doesn't matter because you can plug in an extra 16K of ROM (or RAM!) by using a Program Pak. You can already buy special Program Paks containing EPROMs or RAMs from various sources — but not Tandy as far as I know.

Ins And Outs

In the middle of the main board are two 6821 PIAs. One is used as a memory keyboard interface at address $FF00. The method of scanning the 8 by 7 matrix of keys is similar to that used by the TRS80 Model I — ie a 0 is shifted through Port B of the PIA to which the row lines are connected. If a key is pressed on a low row then a zero appears on the corresponding column.

The second PIA at address $FF20 has a number of uses. It is used as an RS232 serial interface. This is a little unusual in that a special serial interface chip, for example the 6850, is cheap and often thought easier to use. However, readers with a long memory may recall Motorola's MIKBUG program which used a PIA and some software to generate serial signals. There is no disadvantage in using this method and it does save the chip at the expense of some easy software in the BASIC ROM. The serial interface is in fact an RS232 subset consisting of Receive, Transmit and Carrier Detect but these three are more than enough for most applications.

The rest of the PIA has a rather interesting function. Bits PA2 to PA7 are used to generate an analogue voltage between 0 and 5 V in 78 mV steps — ie a six-bit D to A convertor. This is done via an additive network

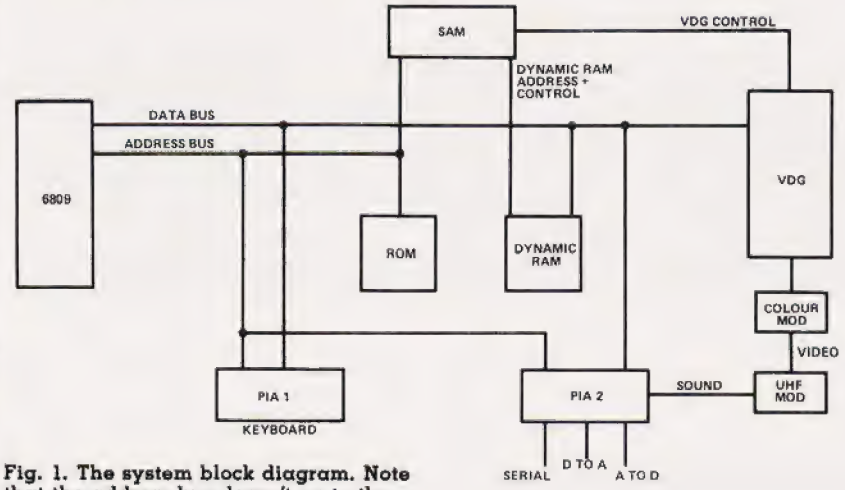


Fig. 1. The system block diagram. Note that the address bus doesn't go to the VDG or the RAM!

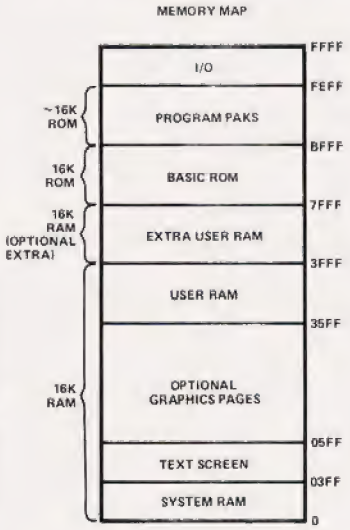


Fig. 2. The system's memory map.

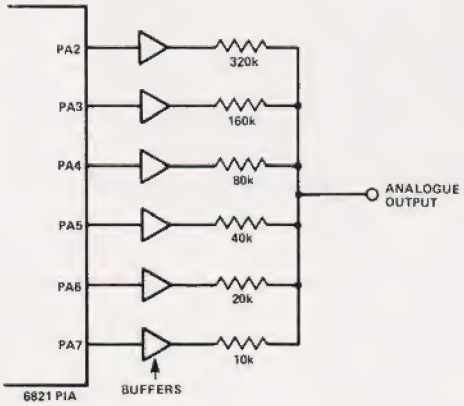


Fig. 3. Using the 6821 to make a D to A converter.

with binary weighting (see Fig.3). This is an easy, cheap way of constructing a D to A converter and like the clever RS232 interface, has no special disadvantages.

The resulting six-bit D to A is used for three different jobs. First it generates the notes required by the cassette interface. Second, it is fed to the TV set as a sound effects generator and third, it is used to make a four channel A to D convertor for use with the joysticks. With all that to do it must feel very tired at the end of the day.

Seriously though, this ingenious use of the same circuit has a few disadvantages for the user. Because it is used as the sound generator, any sounds produced by the machine must be programmed and the only waveforms available in Color BASIC are sinewaves and then only one at a time. If Tandy had used a special sound effects chip they could have offered more than one tone at a time — ie chords, etc. It may be possible to overcome this problem by software but not from BASIC. The four channel A to D converter uses a software successive approximation technique which is reasonably fast. The input voltage must lie between 0 and 5 V and digitisation accuracy is about 40 mV. Its intended use is via a couple of joysticks and the JOYSTICK command but there is no reason why it shouldn't be used for any other not too exacting analogue measurement — don't expect too much from six-bit accuracy.

The discussion of the PIAs has taken us through all of the Color machine's interfaces except one — the expansion port, the details of which can be seen in Table 1. We have also missed one hardware feature that is almost invisible — the real time clock! The 6809's interrupt request line is pulsed every 1/50th of a second and this signal is used to trigger a clock update routine in the Color BASIC ROM. This last feature typifies the Color Computer's approach to things — if you can do it with software then so be it!

The Software

The Color Computer comes equipped with Extended Color BASIC; there was an ordinary Color BASIC in the States but Tandy seem to have skipped that stage over here and gone straight to the more advanced version. Even though the Color Computer uses a 6809, the BASIC is still from Microsoft and has all the standard things like LEFT$, RIGHT$, PRINT USING, etc, etc. So, running other people's programs should be easy.

In addition there are a number of new commands for graphics and game playing. Some of these are very interesting. For example, CIRCLE (x,y),r,c,hw,s,f means plot a circle at x,y of radius r and colour c with a height to width ratio of hw starting at s and ending at f. If that seems like a lot for one instruction, it is! Using it you can plot any part of a circle, or an ellipse, of any colour of any radius anywhere!

Two other commands worth knowing about if only to discover what other machines are lacking are the DRAW and PAINT commands. The DRAW commands will execute a string of graphics commands. So if you want to draw a square you load a string variable, A$ say, with the necessary instructions and type DRAW A$. PAINT is also very useful, for example PAINT (x,y),c,b will fill in an area with colour c. The way the area is defined is that, starting at point x,y, the colour fills the screen but will not cross any line or area drawn in colour b. For example, if you had drawn a square using blue lines, then PAINT (x,y),2,3 would fill the square with yellow if x,y was inside the square. If x,y was a point outside the square, the yellow colour would fill every part of the screen ***except*** the inside of the square.

There are other commands I could list that make Color BASIC very good for graphics, game playing and education. Each would require at least a paragraph to explain so all I will do is to direct you to a Tandy shop to find out about AUDIO, GET, PUT, LINE, COPY, PLAY and SOUND.

TANDY COLOR REVIEWED

Expansion

There are two ways of expanding the Color Computer — Tandy's way and everyone else's way. Tandy's way of expanding the Color Computer uses the Program Pak slot to connect up a 5¼" disc and to load Color Disc BASIC. You can use up to four drives off the same controller, each giving 156K of single-sided double density storage. The Disc BASIC is very similar to the other Microsoft disc BASICs with commands such as OPEN, CLOSE, INPUT, DIR doing most of the work. This is all very well but it ignores the fact that this machine is a 6809 and that there are a lot of 6809 enthusiasts all ready to produce software/hardware expansions.

The standard 6809 BASIC and operating system is TSC BASIC and TSC's FLEX. The standard hardware is the S50 bus (see CT, April 1981) and Tandy's expansion methods isolate you from all the opportunities this offers. However, if you are prepared to import extras from the States, you needn't be cut off! Hardware to connect the Color Computer to the S50 bus or run the FLEX operating systems has been available there for at least six months.

Conclusions

I am enthusiastic about it because it is one of the few machines that uses a 6809. Traditionally, 6809-based systems have been mainly used for technical/commercial applications — SWTP/GIMIX/SSB/MSI equipment for example. However the Tandy Color is, in Tandy's opinion, a HOME computer, for playing games, education, etc and, from Tandy's point of view, the fact that it uses a 6809 seems to be irrelevant. In my opinion this is a great shame.

The trouble is that, as a home computer, even with all its good points, it's a bit on the expensive side. The 16K machine costs £449 in the UK — in the States the same machine costs $559, or approximately £299! Presumably the difference is partly because of the NTSC to PAL conversion. On the plus side, the graphics are stunning and you can make things move around the screen quite fast using nothing more advanced than BASIC. If these features are important to you then you'll be impressed by the Tandy Color Computer — you may be even impressed enough to buy one!

Pin	Function
1	− 12 V
2	+ 12 V
3	HALT
4	NMI
5	RESET
6	E (6809 clock)
7	Q (6809 clock)
8	CB1
9	+ 5 V
10-17	$D_0 - D_7$
18	R/W
19-31	A_0-A_{12}
32	C000-FEFF chip select
33,34	O V
35	Analogue In
36	FF40-FF5F select
37-39	$A_{13} - A_{15}$
40	Decode defeat (turns off internal ROM)

Table 1. The expansion port pin allocation

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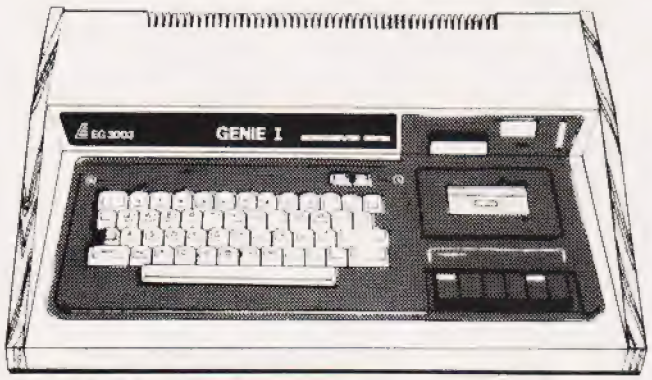

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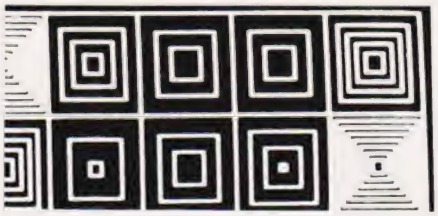
Gateshead NE9 7PU
Tyne and Wear.



Dear Sir,
I purchased the February issue of Computing Today for the specific purpose of furthering my knowledge of Apple Graphics. What a disappointment (euphemism for waste of money).

The vast majority of the article deals with subject matter already lucidly covered in Apple's own exellent manuals which are supplied with the computer. So what on earth is the point of reproducing it?

You specifically avoid shape tables and Hi-res colour where you may have been able to make a helpful contribution!

The short program for bouncing a ball has a bug in it — the ball disappears out of the corners of the frame. No mention is made of the fact that text screen memory locations are not continous — a vital piece of information.

The table headed 'Using Apple's Graphics' is, for a start, a misnomer and additionally, gives no indication of how to use it. Just try PRINTing CHR$(0) to CHR$(63). Do you get white letters on a black background as you suggest? CHR$(65) to CHR$(127), according to your table, should give flashing text. No way! Why could you not have made the simple pont that these numbers have nothing to do with CHR$ function, but have to be POKEd into screen address codes to mean anything?

The only section which might otherwise have been of value was that dealing with the geometry of circles and ellipses. However, the line drawing sections don't work!

There is a scandalous inability of professional writers to communicate clearly with the beginner, and an article such as this not only doesn't help but actually destroys the confidence of the uninitiated. It would, literally, have been more helpful not to have published it at all.

Perhaps the most common and well justified complaint in the business, is the utterly abominable standard of so-called instruction manuals supplied with some computers and their peripherals (Apple specifically excluded). I think one of your prime functions should be to clarify ambiguity and unintelligibility in areas desperately in need of it. Try an Epson printer manual and have a field day — especially if you have an MX 82.

Please, do not publish another beginner's article until you have first allowed a genuine beginner to thoroughly test everything you propose to put in it.

Yours faithfully
J A Trott
County Londonderry
Northern Ireland.

(* I am sorry that Mr Trott was so disappointed with my Apple Graphics article — but none of us can expect to please everybody all of the time. My aim in this particular article was to give Apple owners without much experience a feel for the graphics capabilities of their machines and to provide information about graphics in general to people contemplating buying a micro. Mr Trott is obviously no beginner and so I'm afraid that my article had little to offer him apart from the section on geometry, as he points out himself.

There is indeed a misprint in the second circle program (line 110 — the second pair of THETAs should be THETA + INCs) however, the second ELLIPSE program using the same technique is correct. As for the pinball program, again Mr Trott is correct in saying there is a bug in it. Line 40 should have been Y = RND(1)*38+ 1. The original line makes the ball start outside the frame about once in every 39 times the program is run! As you can guess, the 30 or so times I ran it the ball was placed in the frame so I missed the bug! Such is the problem of testing random programs! As both the circle drawing and pinball programs were illustrating a point rather than being put forward as applications I feel that neither bug spoiled them to the point that they were useless. The main point of the pinball program was to show how a ball can be bounced around the screen and that it does if you read lines 2000-2120! I'm not suggesting that bugs are unimportant in example programs, just that some bugs confuse and destroy their value entirely while others are just irritating.

Mr Trott's comment about the screen memory map being discontinuous is absolutely correct (it is not only discontinuous it is positively mangled!) but it is not a point to include in a beginner's article. I avoid the use of PEEK or POKE for the same reason.

The table of APPLE graphics characters was included to enable the users of other micros to discover what the APPLE has to offer in the way of block character graphics and is part of CT's continuing attempt to catalogue all the available graphics sets — something which I personally have found useful when converting programs for other machines.

As I pointed out, the use of shape tables and hi-res graphics in colour each deserve a whole article to themselves — which I might still write when I recover from the effects of your letter! Mike James. *)

Dear Sir,
I am an electronics lecturer at Napier with a special interest in teaching microprocessor-related topics. I have been involved in microprocurement ranging from desktops such as Apple II, HP85 and PET to single-board micros such as the Rockwell AIM-65. These micros have been mainly used for student project work at degree level and also for staff development. Our main microprocessor teaching laboratory, however, is based around the Mid West Scientific Instrument's version of the Motorola 6800.

Our present policy is to

expand our facilities, still keeping with the Motorola family for compatibility. Apart from having one 6809 as a demonstration unit it was decided to bypass the 6809 and go for the 68000. Because of financial restraints the cheapest option is the 68000 KDM development board linked via a RS-232C interface to a host minicomputer. Our department has one of these and hopes to purchase three more in the foreseeable future.

I would like to have the option of having an on-board ROM assembler for the 68000. This would get us started until the links are put in and the macroassembler is up and running on our minicomputer. It would also give us a measure of independence, for example in cases where the mini is heavily loaded with other traffic or is 'down' for any reason.

I am aware ROM-based assemblers have particular disadvantages. The one we have for Z8000 development board is a line by line assembler which has a restricted instruction set and which does not support program editing in assembly language. We get round this by writing source code twice, once on a rather outdated PDP11/10 retaining the source file there and then downloading the code to the development board where it is assembled. In this way we use the PDP11/10 for editing.

(i) My first query to you is, are you aware of any software house or distributor, UK or American, who could supply us with either a PROM-based assembler for the 68000 or an appropriate assembler listing?

(ii) My second question is a similar one relating to both 6809 and 6800?

(iii) Finally, are you aware of any software house which markets 'simulator' software for 68000 and 6809?

Yours faithfully
Dr James A McClean
Lecturer
Department of Electrical and Electronic Engineering
Napier College of Commerce and Technology
Edinburgh.

(*If any readers can help Dr McClean please write to him at the address above. Ed.*)

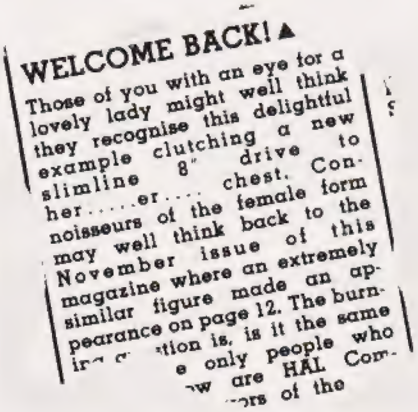
Dear Sir (or Madam?),
Re "Welcome Back" — Consumer News, January 1982.

Yes, there are those of us who don't have eyes for lovely ladies, namely us 'lovely ladies' ourselves!

I'm no bra burner, but why is it that all photos in magazines such as yours depict slinky women (re-) posing across keyboards or 'clutching to their chests' items of computer equipment (as if that were the limit of their capabilities), followed by a dialogue aimed at the male reader? Computing is surely one of the few professions, because of its comparative youth, with a fairly even spread across the sexes.

How about some rugged 'he-men' clutching slimline 8" disc drives to their. . . .er. . . .for a change?

Yours faithfully
G A Waugh (Miss)
Sheffield.


WELCOME BACK! ▲
Those of you with an eye for a lovely lady might well think they recognise this delightful example clutching a new slimline 8" drive to her.....er.... chest. Connoisseurs of the female form may well think back to this November issue of this magazine where an extremely similar figure made an appearance on page 12. The burning ... tion is, is it the same ... e only people who ... are HAL Com... ors of the

(* I only wish that your comment about computing having a fairly even spread across the sexes held true — the number of professional female computer staff is, sadly, much lower than one would expect. Indeed, our annual readership survey indicates that we have less than 5% female readership so your letter is somewhat of a rarity

Your comments on the sexist angle have been noted, I'm sorry if we caused offence but we are limited in the choice of News photographs to those that the various PR companies send us — the pages would look a little silly with blank spaces scattered across them. Ed. *)

Dear Sir,
Last month's CT (February) contained an Auto Line Number program written for a NASCOM supporting NAS-SYS 1. But many owners now have the improved NAS-SYS 3 whose subroutine table exists at #0772 instead of #0778. The table is also six bytes longer due to added commands.

Therefore the following corrections must be made to allow it to execute properly without a systems crash:-

```
0D00 21 82 07    LD HL, #0782
0D06 01 7E 00    LD BC, #007E
```

This may be of some help to those people who suffered brain damage trying to make it execute.

Yours faithfully
D B Richards
Somerset.

Dear Sir,
I have a tale to tell that will be the envy of every prospective micro owner who has endured weeks or even months of waiting for their machines.

Finally deciding to buy a Sharp MZ80K, especially after their recent dramatic price cut, I posted off my order to Knights TV and Computers in Aberdeen on the 23rd December. With it being nearly Christmas I expected a long delay, at least two or three weeks.

Imagine my surprise when the computer was delivered on New Years Eve! A mere eight days later (including Christmas Day), and all the way from Scotland too!

Can anyone beat that for service?

Your sincerely
Martin Houston
Essex.

Dear Sir,
I have been asked by the American commercial UNIX organisation/USR/Group to form a similar group in the United Kingdom. Since the Computer Retailers Association also has an interest in UNIX we will hold a session for all interested parties in Commercial Unix. All parties wishing to attend should write to me at the address given below for details of venue and agenda.

Yours sincerely
Tim Keen
Chairman of the Technical Group
Computer Retailers Association
Owles Hall
Buntingford
Herts. SG9 9PL.

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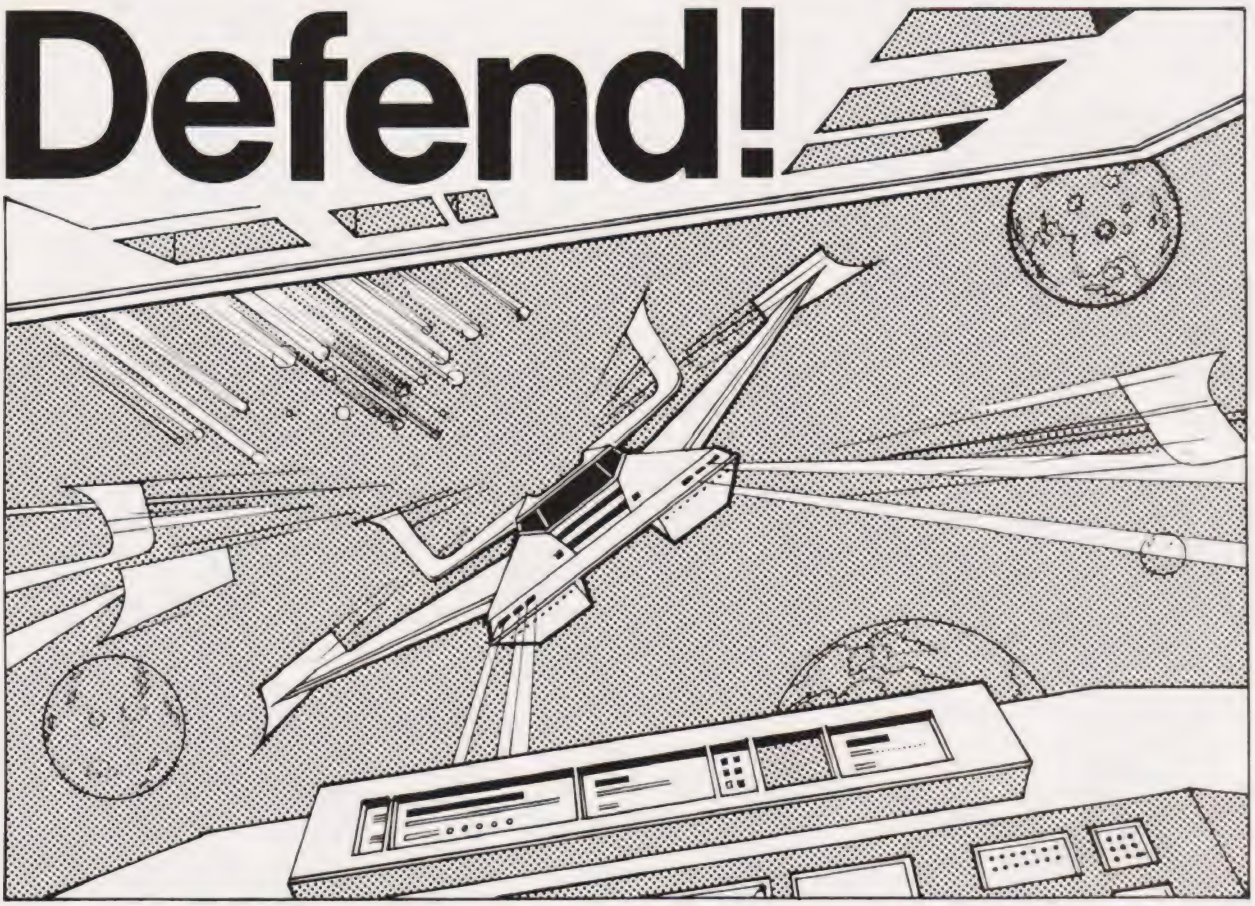

First there was Invaders, then came Asteroids, and now DEFEND!!!

Carrying on in the same tradition, Defend is a fast arcade type action game, complete with sound effects. Enemy spaceships come at you fast and furiously. If you succeed in shooting them down before they get your ships, you must still get yourself through a meteor shower (but at least they don't shoot at you) and finally, if you emerge unscathed, you must navigate a tunnel in order to get yourself completely out of danger. An enthralling game with excellent graphics, personalisation of highest scores and points bonuses. One of its best features is the "crisp" and immediate control the player has over the manoeuvreability of his ship which includes diagonal movement. Machine language, of course, for speed. A matter of taste, but we think it beats Invaders and Asteroids. Suitable for TRS-80 Models I and III and all Genie models.

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LDOS

First there were the TRSDOS's, 2.0, 2.1, 2.2 and 2.3. Then came Newdos +, essentially a patched version of the TRSDOS's but with a number of very useful commands and utilities added. Then VTOS 3.0 and VTOS 4.0. These constituted a departure from the earlier DOS's and featured Device Independence so that devices such as the keyboard, printer, VDU and disk drives could interact directly together. Then came Newdos80 which is a rewrite of Newdos +, adding new utilities and new Basic commands, its main features being the ability to mix different capacity drives on the same cable and the ability to use variable length records. Now from LOBO International comes LDOS, the fifth generation disk operating system for the TRS-80 microcomputer. It combines most of the advantages of the preceding disk operating systems and unlike some of them, is accompanied by a complete and readable set of documentation, which includes a Technical Section containing relevant addresses.

It is impossible to describe all of the features of LDOS in an advertisement. For instance it includes no less than 35 library commands as follows: —

APPEND	COPY	DEVICE	DIR	DO	FILTER	KILL
LIB	LINK	LIST	LOAD	MEMORY	RENAME	RESET
ROUTE	RUN	SET	SPOOL	ATRIB	AUTO	BOOT
BUILD	CLOCK	CREATE	DATE	DEBUG	DUMP	FREE
PROT	PURGE	SYSTEM	TIME	TRACE	VERIFY	XFER

All of the useful abbreviations in Newdos are included and the System Commands in Basic (CMD) now number eleven. A program called LBASIC/FIX is included, with which the normal TRSDOS Disk Basic may be patched to include a number of new commands and features. A Job Control Language is included and in fact is one of the most powerful features of LDOS. It allows the user to compile a sequence of commands or key strokes for later execution as a chain, with or without user intervention. There are too many new features to list them herein, but examples are: The ability to provide an audible signal, output through the cassette port. To flash or blink a one line message on the video display. A WAIT feature is included so that the machine can be put into a "sleep" state until such time as the system clock matches the time specified. And so on!

Hard disks in addition to single/double density, single/double sided, 8" and 5¼" floppies are supported although they may, of course, require hardware modifications. Utilities included in the package are:

BACKUP	COMMAND FILE	FORMAT	LCOMM
PATCH	RS232	KEY STROKE/MULTIPLIER	PRINTER FILTER

A Basic Renumber facility is included, as is a Basic Cross Reference function. Both are similar to the ones in Newdos + and Newdos80. Most of the utilities are library commands which were existent in the previous DOS's, have been improved with the addition of new functions or facilities.

The prime development team of LDOS consisted of no less than 8 first rank programmers and they had the support and advice of six other well known programmers. They have done an excellent job to bring to the user what must be the best disk operating system so far produced for a microcomputer, which is destined to become the Standard DOS.

LDOS is totally upward compatible with TRSDOS, that is to say LDOS will be able to copy files and programs from TRSDOS disks onto LDOS formatted disks. As they are competitive disk operating systems, it is not suprising that the manual states that disks created under Newdos are not guaranteed to be compatible with LDOS, but we have not experienced any difficulty. We have done some work on investigating the compatibility of LDOS and the Video Genie and at the time of going to press we have found no incompatibilities. LDOS appears to run on the Video Genie without any problems at all. LDOS is compatible with either the Tandy or Electric Pencil lowercase modifications and Scripsit. LDOS is available for the Model I and Model III. A Model II version will be available shortly.

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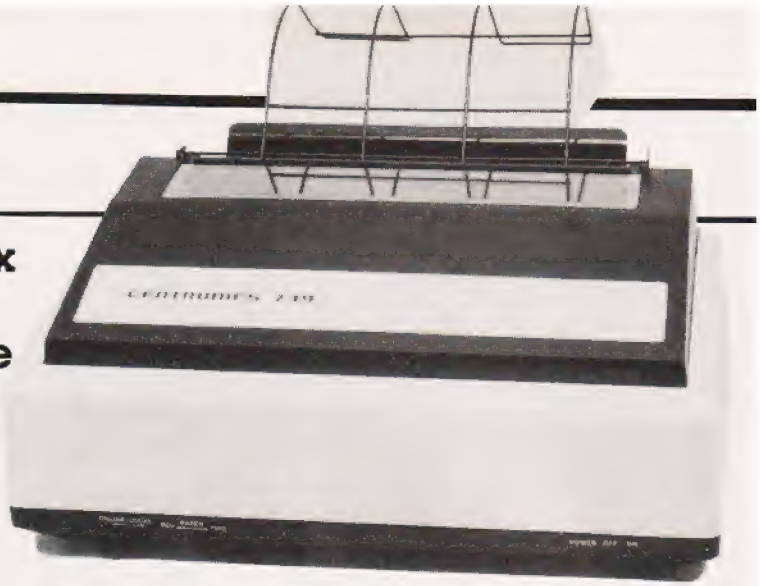
Mike James

With a background in matrix printers like theirs you'd expect Centronics to produce something special. We take a look at their Model 739 and print the results!



Centronics seem to have been making printers since the days when printout came on clay tablets! They are so well known and influential, the standard method of connecting a printer to a small computer using a parallel port is often referred to as a 'Centronics' interface. However, in the past few years, because of the vastly increased demand for printers for personal computers, there have been many newcomers to the field. The requirements of the microcomputer market were (and are) very different from the needs of the traditional mini or mainframe market. In general though, a printer can be evaluated in terms of

1) how fast it can print
2) the quality of the print
3) paper handling features
4) range of character set — including any graphics options
5) COST!

At first the microcomputer community were glad to use any sort of printer as long as it was cheap, but as time went on two types of use emerged. The first was general/technical/programming/commercial where high quality print was deemed less important than speed and low cost, and it was in this field that the standard dot matrix printer dominated.

The second user area was text processing and here only the highest quality print would do.

Centronics, at first, didn't really offer any product that was especially suited to either field. They didn't make a daisy wheel printer and the only very low cost printer they supplied was the P1 Microprinter which used special metal-coated paper. Other printer manufacturers may not have been as well-known or supplied as wide a range but they did use some new techniques to produce versatile low cost printers.

To my surprise at the beginning of last year I came across an advertisement for a very smart looking printer. It was a dot matrix printer with a maximum speed of 50 or 80 characters per second which in itself is nothing special. What made it special was that it claimed to produce 'correspondence' quality output. After examining a sample of its highest quality print, I decide to take the plunge and buy one. This was the first time that a dot matrix printer, the only sort I could afford, had managed to produce a print quality that was good enough (in my opinion) for text processing . . . and the name on the printer was Centronics!

The Centronics 730 range was a fairly big step away from their previous designs. At the bottom of the range — the 730 — this change in design produced a good but unexceptional dot matrix printer. The two machines that are worth examining in detail are the 737, the one that I bought at the beginning of 1981, and the 739, the machine that I would buy if I didn't have the 737 already!

Technical Details

Both the 737 and the 739 feature a 'free flight print head'! This grand title simply means that the head moves itself backwards and forwards across the paper by means of a small electric motor pushing it along a track. The important point is that the electric motor is attached to the print head and so it moves under its own power like a little electric train. This simple design change elminates all the complicated and very delicate bands and belts normally used to pull or push the head about. After using the 737 for a year I can vouch for the reliability of the free flight method of head positioning.

Apart for this innovation, the 730 series are microprocessor controlled. This has little importance for the average user — you can't (easily) gain access to the program it runs — but it does mean that the 737 and 739 are able to offer a wider range of facilities. The 737 and 739 can print 80/132 characters per line, do full — and half-line feeds forward and backward, print double-width characters and use six different countries' character sets. The latter feature mentioned is not as powerful as it might sound because we are not talking about six entirely different character sets but just the substitution of the 12 specific characters, eg where the UK set includes a pound sign, the USA set will have a dollar sign.

I've been leaving the most important feature of the 737 and 739 until last — proportional spacing. The highest quality print that can be produced uses a proportional character set (a proportional character is one that takes up as much room as it requires). In a standard (mono spaced) character set, as printed by a 7 by 8 matrix printer, each character, even a full stop, takes seven horizontal dot spaces. The 737/739s proportional characters take varying amounts of horizonal space from a maximum of 18 dots, 'W', to six dots, 'j'. This variation in width is possible because the free flight head ensures accurate positioning and the microprocessor control provides the necessary intelligence. The impact of all this on the user is that the print quality is surprisingly good.

The one thing that bothered me about my 737 printer was that I knew that it should be possible to control the print head in such a way to make graphics possible — the change would just involve altering the program that the printer's micro was running. Thankfully, before I started to think too seriously about the possibility of the reprogramming involved, Centronics had the same thought and introduced the 739 with full pin addressable graphics. I should say that they not only reprogrammed the micro, they also reworked the electronics and produced a new top cover to improve single sheet feeding, but more of this a little later. Pin addressable graphics means simply that you can send a special code to the printer

that puts it into graphics mode and from then on, every code that you send it is translated into a pattern of dots. You can print 594 dots across the page and as many as you like down the page, so this is high resolution graphics indeed. The real trouble is how to translate a screenful of graphics to a page full of graphics.

The Printer In Use

Both the 737 and the 739 are pleasing to use. They have the feeling of modest quality in that, although their outer case is plastic, Centronics has somehow managed to get the overall proportions right. The printer's size, thickness, etc are well-balanced. Unfortunately they are both noisy. Although the 739 is a distinct improvement over the 737, I can see no obvious cure for the residual clatter — apart from a full acoustic cover.

The three types of paper can be used in the machines: fan fold — almost impossible to insert without wasting the first couple of sheets; roll paper and single sheet. Single sheet feeding is especially easy on the 739 with its redesigned top cover as a large clip-type guide is provided. While on the subject of paper handling, I should mention that the fan fold paper required for use is the standard 9½" width. This seems reasonable except that the nearest size of computer stationery to A4 is 9¼" by 12" and this cannot be used. (Well, if you're prepared to mutilate your printers' adjustable pinfeed by enlarging the slots you can just fit 9¼" paper. It's a modification that I made to my 737 sometime ago but don't tell Centronics!).

For good quality printing the newness of the ribbon is critical. Unfortunately the life of the standard ribbon is, in my opinion a bit on the short side and although fitting a new ribbon is easy, it can be messy if you make a mistake.

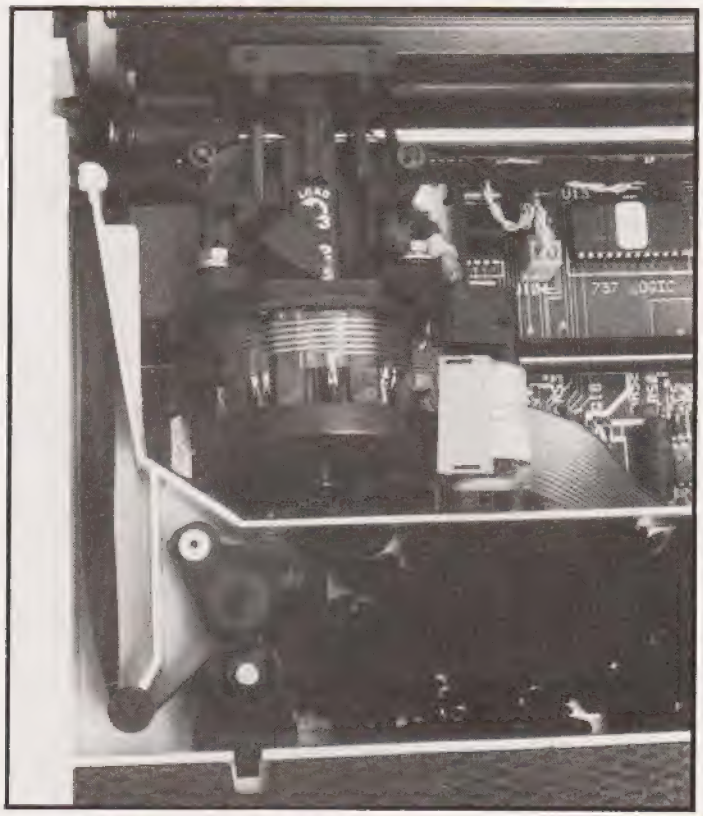
One last slight niggle is that some of the options such as character set and auto carriage return after line feed are not software selectable. They can only be changed by lifting the cover and altering some internal switches and Centronics are careful to say that any damage that you do to the printer (or yourself?) while doing this is your own fault!

Even though I've a few criticisms, overall the 737 and the 739 are two of the best printers that I have used. The trouble isn't the hardware, it's the software! To get the best from either printer it is necessary to have a text processor that supports proportional spacing and — for the 739 — a program to do a screen dump would be an advantage. There are now some text processors that will use proportional spaced character sets but these are recent products. If you use a conventional text processor and print with the proportional spaced character set, the result is the loss of any justification.

The same problem of software has to be overcome if you want to use the 739 as a graphics printer. I believe there is a program for the Apple but if you want a graphics printer, check that the 739 can be used with your system or that you can write the necessary software.

Conclusions

The Centronics 737 and 739 are not absolutely perfect but they do form one of the lowest cost routes to high quality printing provided you can buy (or write) the necessary software to make use of the proportionally spaced character set. In addition, the 739 offers high resolution graphics but here again you encounter the question of software, although in this case the problem is easier to solve. In the year that I have used the 737 it has given no trouble and the print quality seems as good as the day I first used it. If I were buying a printer again I would probably choose the Centronics 739 — can there be any higher recommendation!



Above: The main control switches are conveniently located at the front of the printer.

Left: The free-flight head can be adjusted for multiple copies. The ribbon is stored at the front of the printer.

Below: An example of the Hi-Res graphics output.

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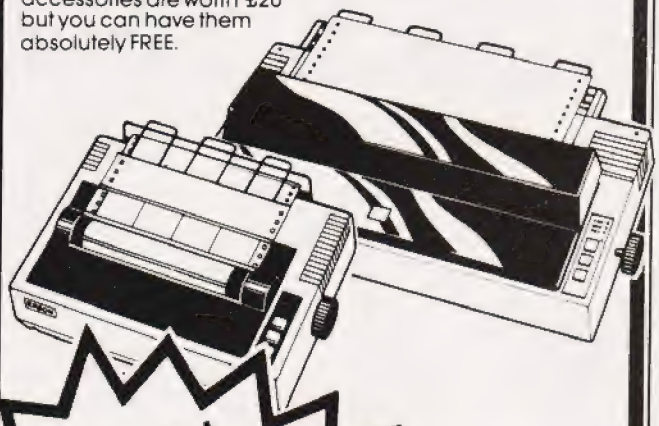

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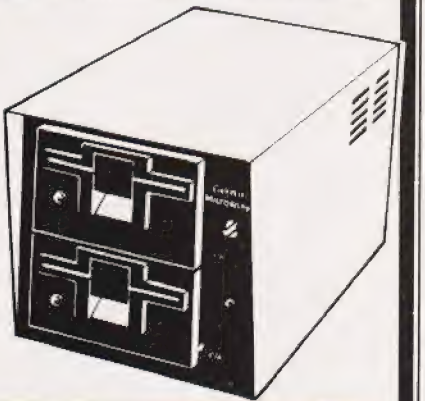

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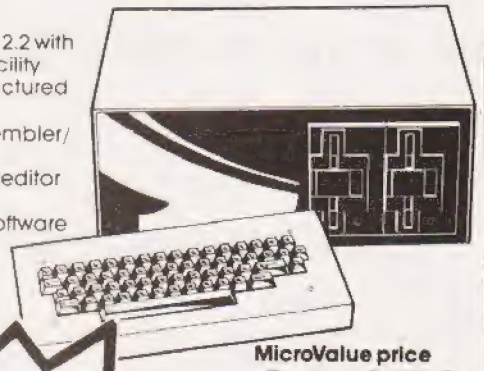

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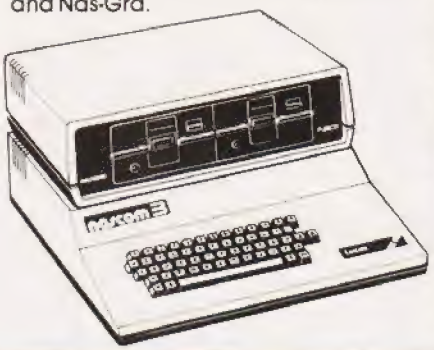

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GOING FORTH

D S Peckett

The final part of our popular series sets out to explain the operation and structure of a working FORTH program.

We have now looked at the main elements of FORTH and, after the initial shock, found it to be a very unusual language which has some significant advantages over 'conventional' languages such as BASIC. In particular, it runs about 10 times faster than your average BASIC and, once you have mastered the knack of thinking backwards, program development time can be considerably shortened. When you add to this the astonishing flexibility of FORTH and the fact that it is ideally suited to structured programming, you start to wonder why you have been wasting your time with boring old BASIC, Pascal et al.

What we have not done so far though, is to put all these wild claims to the test by actually writing a FORTH program! This month we will, by means of the classic 'Towers of Hanoi' problem; there are a number of reasons for this choice:

a. It has well-established solutions which allow us to concentrate on writing a program without having to solve the fundamental problem as well.
b. It is a good example to show the sheer speed of FORTH.
c. It is the right size for an article like this.
d. Last, but not least, the Editor suggested it!

Remember that, where there might be any confusion, FORTH words and groups of words will be enclosed in square brackets — **[ ]**. The brackets themselves are not part of the language.

The Towers Of Hanoi

First of all, let me refresh your memory as to just what the 'Hanoi' problem is. There are lots of legends associated with it but in essence, the problem centres on three rods, one of which has a number of discs on it. The discs are of different sizes and are arranged so that any disc always has a smaller one on top of it. Your job is to move the file of discs to another rod, moving one at a time in such a way that a larger disc never lies on top of a smaller one.

Put like that it sounds simple, and it is. It just takes a terribly long time — the minimum number of moves needed to transfer (n) discs is given by $(2^n - 1)$. In other words, it would take 1023 moves to shift a 10-disc pile, or 1,048,575 moves for 20 discs. Definitely a job for a computer.

There are many ways of solving the problem on a computer but the neatest, and perhaps the best known, uses a recursive algorithm. Recursion is a bogey word to some people but it really is nothing to be afraid of — all it means is that a subroutine can call itself. Usually each call nibbles away at the problem until, at the end of a whole series of nested calls, the problem is solved and the system backs its way out of the calls. For example, a recursive pseudo-language procedure to drink a glass of beer is:

```
Procedure DRINKBEER
   Begin
      Take a swig
      If glass not empty then
      DRINKBEER
   End
```

Easy, isn't it — it makes you keep taking a swig until the beer's all gone and then you stop.

Suppose now that your 'Hanoi' set has three rods, numbered 0, 1 and 2. A recursive routine to move N discs from rod 'SOURCE' to rod 'DEST' is :

```
Procedure HANOI(N,SOURCE,DEST)
   Begin
      If (N>1) then HANOI(N-1,
      SOURCE,(3-SOURCE-DEST))
      Move disc N from SOURCE to DEST
      If (N>1) then HANOI(n-1,
      3-SOURCE-DEST),DEST)
    End
```

The bracketed variables after the function name (HANOI) merely imply a mechanism for passing data into the routine.

I do not intend to go into the how and why of the procedure since that is not the object of this article; I simply ask you to accept that it does work. If you want to know more about its action, try running through it with a pile of counters, a pencil, and some paper.

Specifying The Program

What else must the program do? As well as implementing the algorithm, it must do a number of other things — in particular, it must give ways of starting, repeating and stopping the run.

Futhermore, it must also output the moves it is making. Since it is being written for a TRS-80 or Video Genie, both of which have reasonable pixel graphics, the program should show the discs actually moving from rod to rod, and also print out which disc is being moved at any time. Finally, the program should be able to handle up to 20 discs and as there is no point in moving less than two, this implies a need for some sort of input checking.

Programming The Solution

After the build up, take a look at Listing 1. You will see instantly just how odd a FORTH program can look. The listing fills six MMSFORTH blocks and I have numbered them 100-105. The operating system accesses blocks by number and 100+ is convenient.

Remember that FORTH programs, like Pascal ones, are constructed from a series of building blocks with the simpler words being compiled first so they can be used to form more complex words. You should therefore start reading the program at the end of Block 105 where you see the word HANOI on its own. This is clearly being used in the immediate mode — it is not in a colon definition — and its job is to run the whole program automatically as soon as it has been compiled. In this way it is easy to give FORTH programs an auto-start capability.

HANOI is defined in line 12 of Block 105 and is formed from four major new words:- TITLE, INIT, SHIFT and AGAIN. The last three are nested in a BEGIN. . . .END loop to allow you to repeat the program as often as you like. INIT simply sets up the system, AGAIN checks to see if the program is to be run again, while SHIFT is the FORTH implementation of the algorithm above.

Before we go on to look at the four words of HANOI, study Block 100 which contains a number of utility words used throughout the program. The block starts with a TASK definition defining the start of HANOI in the system dictionary; this allows you to erase the whole program with a FORGET TASK.

Virtually all the program's calculations are performed on the stack but I found the need for a three element array holding the number of discs on each rod. Normal FORTH does not provide arrays so I had to extend the language to add them. The variable definition of

PILETOTAL reserves two bytes in the system for it leaving a pointer, [H], to the next storage space for words or data. The [4 H +!] simply increments [H] by 4, leaving PILETOTAL pointing to a reserved block of six bytes capable of holding the three elements of the array.

That is fine but we still need a way of implementing each element and, in particular, of getting any element onto the stack or of putting <TOS> into any element. Suppose that we wish access element <n> by [n PILETOTAL]. Remembering that executing the word PILETOTAL puts the address of the first of the six bytes in <TOS>, I hope that you can see that AGET, defined as [SWAP 2* +], converts that address and <n> into the address of the first byte of array element <n>. Think about it anyway. Having defined AGET — [A!] and [A@] are easy.

If you use this sort of construction, be careful. There is no array bound checking in AGET so there is nothing to prevent, say, [20 PILETOTAL A!]; this would undoubtedly crash the system by corrupting the dictionary. It was my choice not to check array bounds however and I could easily have extended AGET to do the job. (How?).

Block 100 also contains three other utility routines: 2DUP, 2OVER and [1>]. They are all very simple and 2OVER shows a typical application of <R and R>.

Line 12 of Block 100 gives the definition of TITLE, which displays the name of the program for a short period each time that it is run. It contains several FORTH words which may be new to you. CLS is an MMSFORTH extension for the TRS-80 and is identical to the CLS in Level II BASIC — it clears the screen and puts the cursor at top left. ECHO outputs the TOS value to the screen as an ASCII character; in this case, [23 ECHO] is the same as Level II's 'PRINT CHR$(23)' and selects double-width letters. PTC is another MMSFORTH extension and its job is to put the cursor at the row (0-15) defined by <20S> and the column (0-63) at <TOS>.

Wrapping-up Block 100, CHECKNO is used to adjust the value at TOS to lie in the range 2-20 inclusive. I described a similar word last month.

Let's go back to line 12 of Block 105. The next word used by HANOI is INIT, defined in line 2 of Block 103 from five other words. The first of these words, GETNO, is straightforward and simply inputs and checks the number of discs to be moved. It also puts 2 and 0 at <30S> and <20S> respectively to define that discs will move from Rod 0 to Rod 2.

SETPILE'S only job is to set the three elements of PILETOTAL to the initial totals of discs on each rod. Rod 0 obviously receives the number at <TOS>, the number to be moved, while the other two are initialized to zero.

LINEDRAW uses the Level II graphics, accessing them directly via FILL, to draw a line across the bottom of the screen for the piles of discs to "stand" on. It also numbers the positions of the three rods by means of the PUT word defined in line 3 of Block 101. PUT uses [<# # #> TYPE], which operates on the value at <TOS> to give an effect equivalent to "PRINT USING "#";N;" in BASIC. The [<#] and [#>] define the start and end of the format field while the number of hashmarks between them defines the width of the field to be output. Together they convert the number at <TOS> into a character string suitable for TYPE to output.

The next word in INIT is PILEDRAW which draws the number of discs at <TOS> on Rod 0 to define the start position. It is defined in line 11 of Block 102 and is basically a DO....LOOP setting up a number of calls to DISKDRAW which actually draws the discs. DISKDRAW expects to receive the number of the rod it is to draw on at <TOS>, the height (ie the number of disks on that rod) at <20S> and the disc number (which defines its size) at <30S>. SETUP then manipulates these values into suitable values for the graphics commands of DISKDRAW. The SETUP definition shows some typical FORTH arithmetic; it is quite difficult to follow and so Fig. 1. shows what happens on the stack when [10 12 1 SETUP] is executed.

STACK										
		42	2	4				42		20
1	2	2	42	42	38	10	1	1	42	42
2	1	1	1	1	1	38	10	10	10	10
10	10	10	10	10	10	1	38	38	38	38
	SWAP	42	SWAP	2*	–	ROT	ROT	42	*	20

	10		52				2			
62	62	52	52	52	10	20	20	22		52
10	10	10	10	10	52	52	52	52	74	74
38	38	38	38	38	38	38	38	38	38	38
+	OVER	–	DUP	<R	SWAP	2*	2	+	+	R>

Fig. 1. The stack before and after the execution of 10 12 1 SETUP.

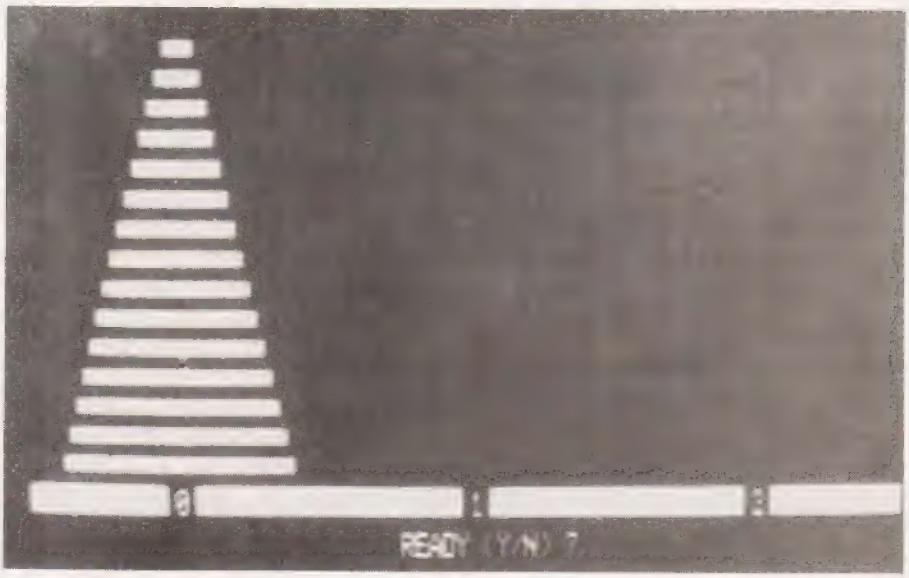


Fig. 2. The screen display when the program is waiting for a user response.

DISKDRAW uses a MMSFORTH graphics extension, ESET. It works in a similar way to the Level II graphics commands; for instance, [y x ESET] is identical to BASIC's 'SET (x,y)'. Later on we will meet [ECLR], equivalent to L II's 'RESET ()'.

Shifting It

The most important new word in the program is, of course SHIFT, which implements the 'Hanoi' algorithm. The word is defined by lines 3-6 of Block 105; to follow it, you must recall that the 'N','SOURCE' and 'DEST' of the definition above are at <TOS>, <2OS> and <3OS> respectively whenever SHIFT is accessed. At least, the word assumes that the top three items of data on the stack represent that information.

With that data, it should be fairly easy to relate the sequence of SHIFT to the pseudo-language definition. Because all the data for the word is passed on the stack, the two words 1RECURSE and 2RECURSE are used to adjust the top three items to the values demanded by the algorithm. In fact, they both put three new items on top of the existing stack because each recursive call of SHIFT must preserve the existing parameters against the time that the program takes to work its way back down the nested list of calls. Figure 3 shows the action of 1RECURSE on a stack whose top three items are 8, 1 and 2. Since each call of SHIFT preserves the stack parameters, its final act must be to get rid of the top three items on the stack; if it did not do this, the stack would eventually overflow and crash the system.

SHIFT itself is not very complicated but one of its constituent words, MOVE, does quite a lot. This word actually shifts the discs around on screen and updates the program's counters. It does its work in the four stages implicit in the four words making it up.

The first job is to blank out the top disc on the 'SOURCE' (ie <2OS>) rod. BLANKDISK sets the height of the disc from the relevant element of PILETOTAL and converts the height (the number of discs in the pile) to screen-based co-ordinates. Using a DO....LOOP, it then blanks out a line of 44 pixels at that height, centred on the rod. Since the maximum disc width is 42 pixels ((disc No. 20) * 2 + 2), this guarantees to remove the disc from the display.

STACK										
								8	1 8	7
		3	2		1		1	1	1	1
	2	2	3	1	1	0	0	0	0	0
8	8	8	8	8	8	8	8	8	8	8
1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2
	2OVER	3	SWAP	–	2OVER	–	2OVER	2OVER	1	–

Fig. 3. The stack building under the recursive use of 1RECURSE.

DRAWDISK then draws the same disc as the top element in the pile on the DEST (<3OS>) rod. The word sets the numbers of the disc (and hence its size) and the destination rod (and hence the horizontal position) off the stack; the height of the new disc comes from a look at PILETOTAL(DEST). The disc is actually drawn by the DISKDRAW word which we met earlier; all the rest of DRAWDISK is concerned with setting up the stack to get the disc in the right place.

The third element of MOVE is ALPHA, which writes out the values of 'N', 'SOURCE' and 'DEST' in the right places in the progress line in the last line of the screen. The word pulls the relevant data off the stack, without disturbing the top three, or any other items. The [DUP 10 < IF SPACE THEN] in ALPHA is used to line up the 'units' digit of the disc number in its field.

Finally, UPDATE adjusts the relevant elements of PILETOTAL to decrement the number of discs on the 'SOURCE' rod and increment the 'DEST' total. Its action should be clear from the code.

If you have kept up so far, Fig. 4 will come as no surprise. For the rest of you, read the description of the program again (a recursive read?) before you look at the photography illustrating the display on the screen part-way through a run of the program. As you see, it shows the discs and where they are as well as displaying which disc is being moved.

At the end of a run on the program, AGAIN is used to create a display like that of Fig. 5. The system is waiting for a yes/no response and, depending on the answer, the BEGIN....END loop of HANOI will repeat the whole sequence or shut the system down.

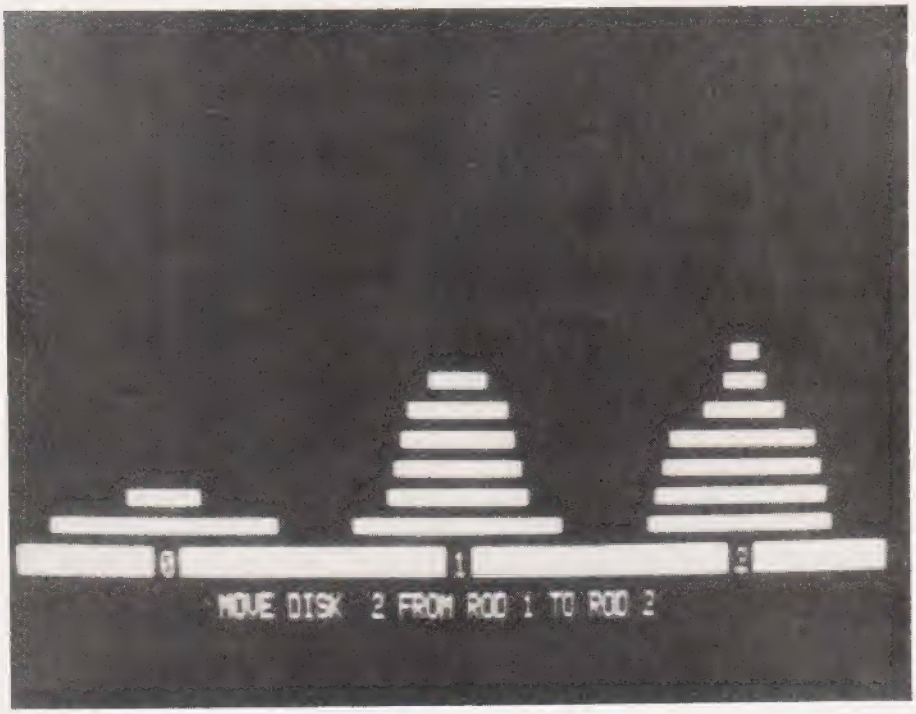


Fig. 4. The screen display while discs are being transferred.

The Program In Use

That then, is a typical FORTH program. It is compact (most of the listing is blank space and/or comment and the compiled code occupies 1037 bytes) and it runs very, very fast. As an indication of its speed, it can transfer a 12-disc pile in 232 seconds. To put that in perspective, I wrote an equivalent BASIC program which was reasonably optimised to run quickly; it took 2220 seconds to move the same 12-disc pile. The program is so fast that it is quite impossible to see the individual discs moving. During its development I wished to see just what was going on and to do this, I needed to modify the second line of SHIFT to:

```
MOVE 1000 0 DO LOOP
```

to get it run slowly enough to follow.

In fact, most of the program's run is taken up with driving the graphics display which could be eliminated by altering MOVE to:

```
: MOVE  ALPHA UPDATE ;
```

The 12-disc pile was then shifted in 100 seconds! A similar amendment to the BASIC version produced a run time of 530 seconds.

Conclusions

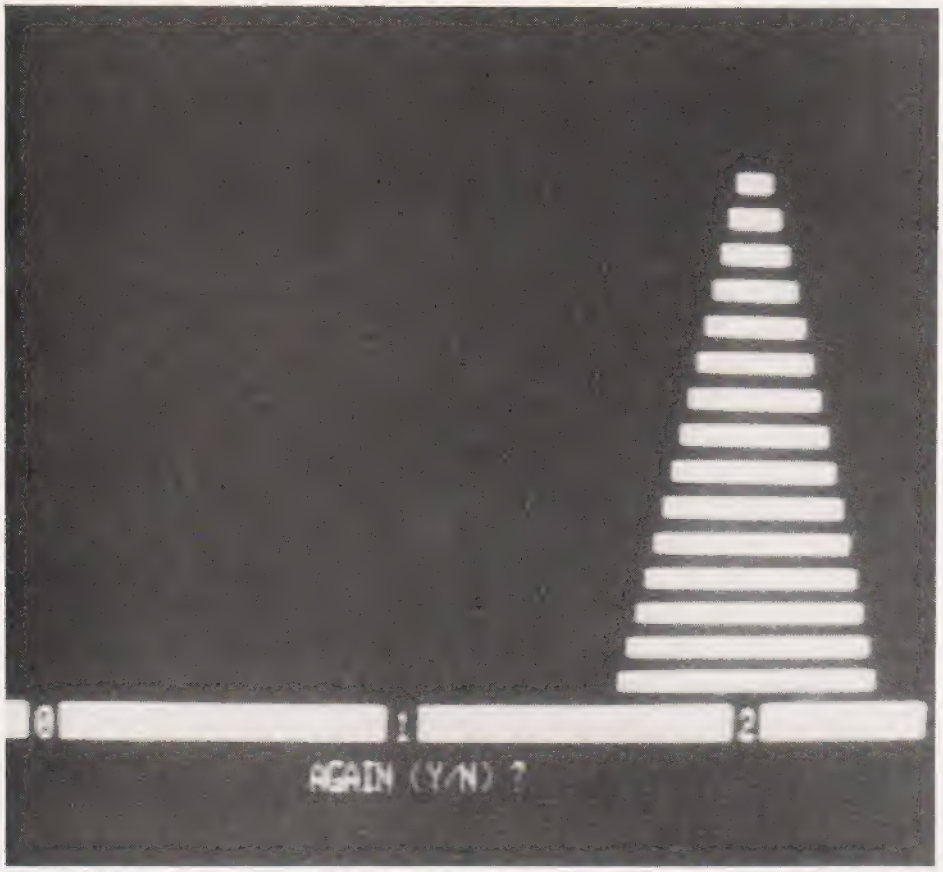
In this series, we have taken an introductory look at FORTH and the way that it should be used to write programs. This month's 'Towers of Hanoi' example gives a good idea of language might look like. It is not limited to gaming however, although its great speed makes it much more useful than BASIC for dynamic games. The language is becoming widely used for process control in such applications as machine-tools and astronomical equipment, where its speed, easy development and compactness make it very attractive

In the future, we are likely to see a much wider use of FORTH as a personal computer language, bringing the advantages of structured programming and modular development to those who cannot afford the discs, etc needed to support the great god Pascal. There are already versions of the language available for virtually all common micros and most system owners can, in fact, choose from several implementations.

Those of you who have seen FORTH before will have realised that in this series, I have only skimmed the surface of it. I have not

```
 0 ( BLOCK 100    1 OF 6          TOWERS OF HANOI        7/12/81      )
 1 (              A PROGRAM IN MMSFORTH                                )
 2 ( REQUIRES MMSFORTH GRAPHICS COMMANDS FOR TRS-80                    )
 3 : TASK ;                          ( DEFINE THE START OF THE PROGRAM)
 4 0 VARIABLE PILETOTAL 4 ALLOT +1      ( PILETOTAL IS 3 ELEMENT ARRAY)
 5 : AGET      SWAP 2* + ;           ( GET THE <2OS> ELEMENT ONTO STACK)
 6 : A1        AGET ! ;                          ( ARRAY EQUIVALENT OF 1)
 7 : A2        AGET @ ;                          ( ARRAY EQUIVALENT OF @)
 8 : 2DUP      OVER OVER ;       ( DUPLICATE <TOS> AND <2OS> IN ORDER)
 9 : 2OVER     <R OVER R> SWAP ;      ( PUT A COPY OF <3OS> ON <TOS>)
10 : 1>        DUP 1 > ;           ( SAVE <TOS> AND TEST FOR BEING >1)
11                                                                    )
12 : TITLE     CLS  23 ECHO 4 1 PTC      ( SELECT DOUBLE WIDTH CHARS)
13             "  WELCOME TO THE TOWERS OF HANOI"                     )
14             20000 0 DO LOOP ;                        ( A SHORT PAUSE)
15 : CHECKNO   2 MAX  20 MIN ;           ( PUT <TOS> IN RANGE 2 - 20)

 0 ( BLOCK 101    2 OF 6          TOWERS OF HANOI        7/12/81      )
 1
 2 ( DRAW THE BASE LINE ON WHICH DISCS WILL BE MOVED                   )
 3 : PUT       133 ECHO <# # #> TYPE 138 ECHO ;  ( DRAW ROD NUMBERS)
 4 : LINEDRAW  CLS 143 16256 64 FILL 14 9 PTC 0 PUT
 5             14 30 PTC 1 PUT 14 51 PTC 2 PUT ;
 6
 7 ( INPUT AND CHECK THE NUMBER OF DISCS WHICH ARE TO BE MOVED         )
 8 : GETNO     CLS  2 0  6 5 PTC              ( 2, 0 DEFINE TO, FROM)
 9                  " HOW MANY DISCS DO YOU WANT TO MOVE (2-20)"
10                  #IN CHECKNO ;       ( EXIT WITH NUMBER ON <TOS>)
11
12 ( INITIALISE ROD TOTALS - ALL DISCS ON ROD 0, OTHERS EMPTY         )
13 : SETPILE   DUP   0 PILETOTAL A!   0 1 PILETOTAL A!
14                   0 2 PILETOTAL A! ;
15 : LINECLEAR  32 16320 64 FILL ;                ( CLEAR BOTTOM LINE)

 0 ( BLOCK 102    3 OF 6          TOWERS OF HANOI        7/12/81      )
 1
 2 ( WHEN TOS=A, 2OS=B, 3OS=C, DRAW DISC 'C' HEIGHT 'B' ON ROD 'A'     )
 3 ( SET UP THE STACK FOR DISKDRAW:                                    )
 4 (       TOS=XSTART OF DISC, 2OS=XFINISH OF DISC, 3OS=YPOSITION      )
 5 : SETUP      SWAP 42 SWAP 2* - ROT ROT          ( YPOSITION=42-2*B)
 6              42 * 20 + OVER - DUP <R            ( XSTART=42*A+20-C)
 7              SWAP 2* 2 + + R> ;              ( XFINISH=XSTART+2*C+2)
 8 : DISKDRAW   SETUP DO DUP I 3SET LOOP DROP ;      ( DRAW THE DISC)
 9
10 ( DRAW THE TOTAL NUMBER OF RODS TO BE MOVED ON ROD 0 POSITION       )
11 : PILEDRAW  DUP 0 DO DUP I - I 1+ 0 DISKDRAW LOOP ;
12 ( WAIT UNTIL READY TO START, AND SET UP BOTTOM LINE                 )
13 : WAIT      BEGIN  LINECLEAR  15 26 PTC " READY" Y/N NOT END
14             LINECLEAR  15 14 PTC
15             " MOVE DISC    FROM ROD    TO ROD    " ;

 0 ( BLOCK 103    4 OF 6          TOWERS OF HANOI        7/12/81      )
 1
 2 : INIT     GETNO SETPILE LINEDRAW PILEDRAW WAIT ;    ( INITIALISE)
 3 : ADEC     AGET -1 SWAP +! ;          ( DECREMENT AN ARRAY ELEMENT)
 4 : AINC     AGET 1 SWAP +! ;           ( INCREMENT AN ARRAY ELEMENT)
 5 : UPFROM   OVER PILETOTAL ADEC ;       ( DECREMENT THE 'FROM' ROD)
 6 : UPTO     2OVER PILETOTAL AINC ;        ( INCREMENT THE 'TO' ROD)
 7 : UPDATE   UPFROM UPTO ;          ( UPDATE RECORD OF QTY ON EACH ROD)
 8 ( PRINT WHICH DISC IS MOVED, AND THE MOVE THAT IT MAKES             )
 9 : ALPHA    15 23 PTC DUP DUP 10 < IF SPACE THEN .            ( DISC)
10            15 35 PTC OVER .  15 44 PTC 2OVER . ;             ( RODS)
11
12 ( DRAW THE MOVED DISC IN ITS NEW POSITION                           )
13 : DRAWDISK   2OVER SWAP DUP ROT DUP PILETOTAL A
14              1+ SWAP DISKDRAW ;
15

 0 ( BLOCK 104    5 OF 6          TOWERS OF HANOI        7/12/81      )
 1
 2 ( BLANK THE DISC THAT IS TO BE MOVED FROM ITS OLD ROD                )
 3 : BLANKDISK  OVER DUP PILETOTAL A@ 2* 42 SWAP -      ( YPOSITION)
 4              SWAP 42 * DUP 44 + SWAP          ( XSTART AND XFINISH)
 5              DO DUP I ECLR LOOP DROP ;              ( BLANK IT OUT)
 6
 7 ( MOVE THE TOS DISC FROM 2OS ROD TO 3OS ROD                          )
 8 : MOVE       BLANKDISK DRAWDISK ALPHA UPDATE ;
 9
10 (  ADJUST STACK FOR RECURSIVE CALLS OF SHIFT (SEE TEXT)
11 (  BOTH THE WORDS PRESERVE THE DATA ALREADY ON THE STACK             )
12 : 1RECURSE   2OVER 3 SWAP - 2OVER - 2OVER 2OVER 1 - ;
13 : 2RECURSE   2OVER 2OVER SWAP DUP ROT +3 SWAP - 2OVER 1 - ;
14
15

 0 ( BLOCK 105    6 OF 6          TOWERS OF HANOI        7/12/81      )
 1
 2 ( SHIFT IS THE WORD THAT ACTUALLY CALCULATES THE HANOI SEQUENCE)
 3 : SHIFT      1> IF 1RECURSE SHIFT THEN              ( RECURSIVE CALL)
 4              MOVE                    ( ACTUALLY MOVE THE RIGHT DISC)
 5              1> IF 2RECURSE SHIFT THEN              ( RECURSIVE CALL)
 6              DROP DROP DROP ;                    ( TIDY UP THE STACK)
 7
 8 ( OFFER THE CHANCE FOR ANOTHER RUN, AND ACCEPT THE ANSWER            )
 9 : AGAIN      LINECLEAR 15 26 PTC " AGAIN" Y/N ;
10
11 ( FINALLY, HANOI IS THE WORD THAT FORMS THE WHOLE PROGRAM            )
12 : HANOI      TITLE BEGIN INIT SHIFT AGAIN END ;
13
14                              HANOI                    ( RUN IT!)
15
```

Listing 1. The complete MMSFORTH listing of the solution to 'The Towers Of Hanoi' problem. The 'screen' format has been retained.



even looked at how strings and double-precision and/or floating-point numbers could be provided; neither have I given any indication of how to provide the essential feature for all gamesters, a random-number generator. Most commercial FORTHs include such features but, when they do not, it is always easy to add them.

The language is not just limited to defining new words from old, powerful though that feature is. With only a little more effort, we can create whole new classes of words by defining new defining words. With such a facility we could, for instance, have created a new word type called ARRAY allowing us to access any element of an n-dimensional array without the fiddling about we had to use in HANOI.

FORTH is truly limited only by your own imagination. I hope that some of you will want to sample it further and join the ranks of those who GO FORTH.

Fig. 5. All done! The program will let you repeat the sequence using a different number of discs if you wish.

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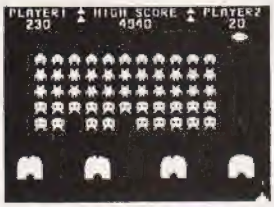

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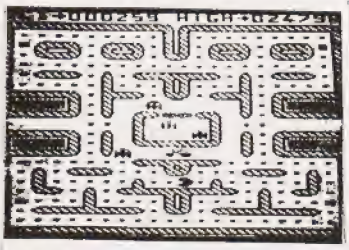

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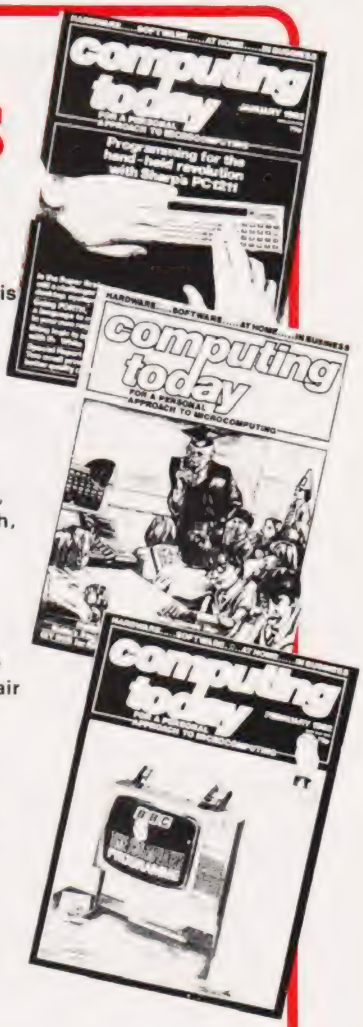

Last month's issue is still available as well but has not yet reached the end of its 'shelflife' and is not included for this reason.

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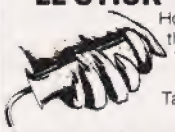

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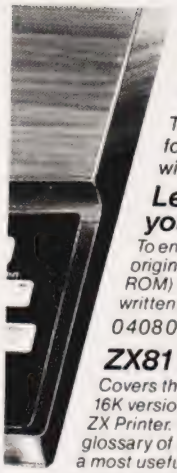

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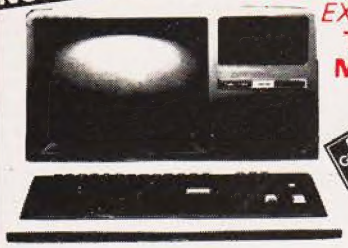

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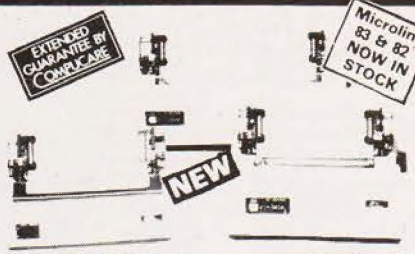

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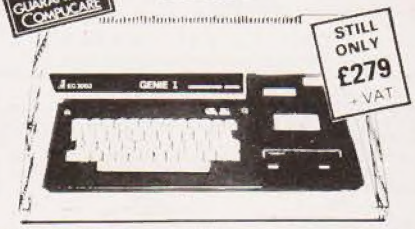

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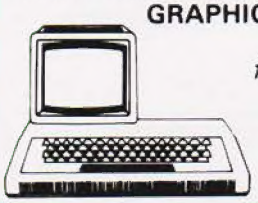

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